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SOILS OF ISRAEL AND THEIR SIMILARITY TO SOILS OF THE UNITED STA--ETC(U)

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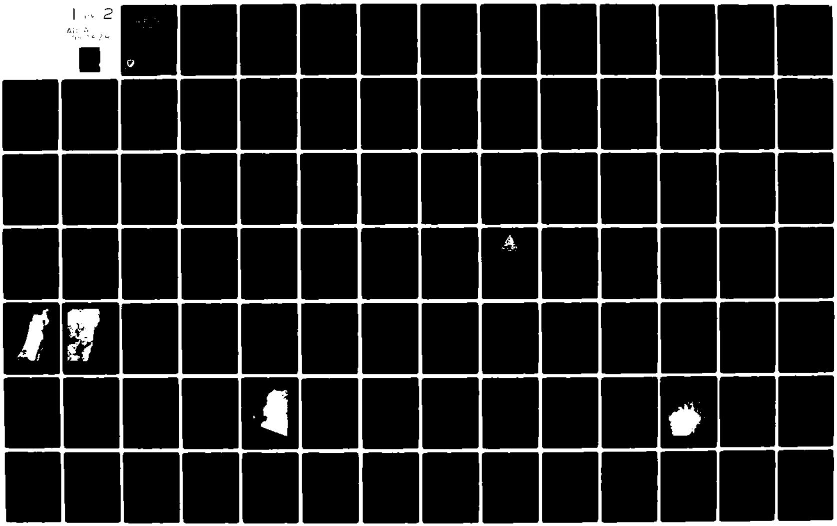

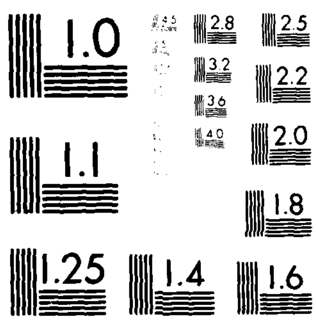

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SOILS OF ISRAEL AND THEIR SIMILARITY TO SOILS OF THE UNITED STATES

FINAL REPORT

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For

US Army Atmospheric Sciences Laboratory
White Sands Missile Range, New Mexico 88002

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US Army Electronics Research and Development Command
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This report compares the soils of Israel, particularly those of the Negev, with various sites in the southwestern United States. Comparison is made on the basis of agricultural maps because of the general availability of this type of information on a world wide basis. Even though the soil mapping units are in agricultural terms, they have been successfully used for nonagricultural purposes.

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20. ABSTRACT (cont)

Among the areas compared, Fort Irwin, California, and Yuma Proving Ground, Arizona, are closest in comparison. However, major differences are noted. A table is provided for quick reference comparing similar families, subgroups, great groups, suborders, and orders.

PREFACE

The US Army Atmospheric Sciences Laboratory (ASL) has been involved in an extensive program to investigate dust obscuration at visible, infrared, and millimeter wavelengths. One goal is to develop and validate models to quantitatively describe obscuration using inputs which are available from the climatology and soils data bases.

The following report is an initial attempt to look at the types of soil information that are readily available on a worldwide basis and to see how they might be used to extrapolate the ASL dust obscuration modeling. It was initially decided to look at those geographic regions which may be of political or military interest for which dust obscuration may be important in military operations. Israel has soil regions which seem to be representative of the Mideast. Since Israel has studied their soils extensively, it was decided to focus initially on those Mideast type soils in Israel and to compare them to soils within the Continental United States (CONUS). To further narrow the study, it was decided to limit the comparisons to military bases in the CONUS, since most large scale obscuration tests would probably be limited to CONUS military bases.

Four bases (Fort Irwin, Fort Huachuca, Yuma Proving Ground, and White Sands Missile Range) were initially selected as being representative of desert environments and their soils and climates were studied in detail for these comparisons.

Several general comments should be made on the types and potential uses of the soils data base. It should be recognized from the start that the soils data bases and classification schemes were developed primarily for agricultural and civil engineering purposes and to classify soils according to soil genesis. For example, the surface soil within and around the Negev desert is classified as loess (deposited by the wind). Those in the southwestern CONUS are not generally considered loess. However, their texture, mineralogy, and soil moisture (parameters important to obscuration modeling) may be the same--just their origins are different. Surface soils (approximately the first 10 cm) are not commonly treated in soils classifications because of their variability. However, these surface soils can play an important role in obscuration effects. Important factors in obscuration modeling are soil texture (relative fraction of gravel, sand, silt and clay), composition (mineralogy), soil moisture, and vegetative cover. Unfortunately, these quantities, particularly texture and composition, are only available from rather detailed soils maps or must be inferred from the characteristics of the higher (that is, more general) orders of classification. The soils maps of Israel and White Sands Missile Range were the most detailed in information on texture and composition. The maps of Fort Irwin, Fort Huachuca, and Yuma Proving Ground were sufficiently detailed to allow these properties to be inferred.

While in some instances this report can be used to provide more detailed answers to specific questions, general conclusions can be stated here. Within the rather broad classifications of soil taxonomy, the soils of southern Israel do represent the soils generally found in the Mideast. Again, within these rather broad soil types, similar soil types can be found at sites in the United States. However, it should be noted that properties of the surface soils and several properties used in detailed obscuration models are not treated in standard soils data bases. Specific site surveys would be needed to determine these properties.

In summary, it is our opinion that both the southern part of Israel and the southwest CONUS are generally representative of a Mideast environment in terms of dust obscuration. Israel is a highly variable country with a variety of soil types which are generally found within the CONUS, but not necessarily found in the four sites selected for this study (which was aimed primarily at arid environments). Those differences between CONUS and Israeli soils (and their effects on battlefield obscuration) are believed to be small compared to the seasonal and spatial variation which exists within Israel itself. Differences in obscuration between a test conducted in Israel and one conducted in an appropriately selected CONUS site are expected to be smaller than differences between two tests conducted in Israel at the same site six months apart or two tests conducted at the same time in different regions of Israel.

A comparison report, Comparisons of the Climates of Selected Locations in the United States with Climate of Beersheba, Israel, by Claude E. Duchon, describes a comparison of climatology between Israel and the specified location in the United States.

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INTRODUCTION

This study was conducted in order to review the properties of the soils of Israel, in particular the soils near Beersheba and the Negev. The soils of southern Israel were studied because it is thought that the Negev Desert has soils representative of a large portion of the Middle East. Existing information was reviewed and the soils were classified according to the United States Department of Agriculture Soil Taxonomy (Soil Survey Staff, 1975).

The USDA Soil Taxonomy is a multicategoric classification system designed to serve the needs of the National Cooperative Soil Survey. Soil surveys have generally been conducted for agricultural interpretations. The soil mapping units, however, have proven very useful for nonagricultural interpretations. The mapping units have been successfully used by planners who need engineering data. Soil surveys have been used by the military to predict stability for runways, trafficability, etc.

The six categories of this comprehensive, hierarchical soil classification system range from 10 classes in the highest category to more than 11,000 classes in the lowest category. The category order, the highest and most general category, is based on soil forming processes as indicated by the presence or absence of major diagnostic horizons. The category suborder is based on genetic homogeneity. These are subdivisions of orders based on presence or absence of properties associated with wetness, soil moisture regimes, major parent materials, and vegetational effects as indicated by key properties. The category great group is a subdivision of suborders according to similar kind, arrangement and degree of expression of horizons with emphasis on the upper sequum of horizons, base status, soil temperature, moisture regimes and presence or absence of major diagnostic layers. The category subgroup has taxa which represents the central concept of the great group, taxa with properties indicating intergradation to other great groups, suborders and orders, and taxa representing extragradation to nonsoil material. The category family is based on properties important for root growth. The taxa are broad soil textural classes averaged over a control section or the entire solum, mineralogical classes for the dominant mineralogy of the solum and soil temperature classes. The lowest category, series, is based on kind and arrangement of horizons and the component color, texture, structure, consistence, reaction and other chemical and mineralogical properties of important horizons.

The information presented in this report is used to compare the soils of southern Israel to like areas within the United States. This comparison can be used to evaluate the quantity and quality of dust generated when the soils are disturbed. The family categoric level is used for extrapolation. Information at the category series in not generally available on an international basis.

The areas of the United States compared to southern Israel, the Negev, are: the Yuma Proving Grounds in Arizona; Fort Irwin in California; Fort Huachuca in Arizona; and the White Sands Missile Range in New Mexico. With the exception of the White Sands Missile Range, these areas do not have a detailed soil survey. Most of the information available is on general maps at scales of approximately 1:250,000 and smaller. Map units are generally associations of great groups, subgroups, families or series, depending on the location of the survey.

Comparisons of the soils between countries can be made at each categoric level of the USDA Soil Taxonomy. Texture comparisons are important in this study; however, texture does not become an important factor in Soil Taxonomy until the family level. Soils with similar taxa are thought to have had similar genesis and therefore similar properties.

GENERAL DESCRIPTION OF ISRAEL

Israel is in a transition zone between the Mediterranean region and the deserts of Arabia and the Sahara. In terms of climate, Israel can be divided into the following areas (generally eastwest): 1) a humid and subhumid Mediterranean climatic region in the northern part of the country with a mean annual rainfall >500mm; 2) semiarid (300-500mm) and arid (80-300mm) zones in the central part; and 3) in the south, an extremely arid zone with <80mm rainfall (Dan and Koyumdjisky, 1963).

Israel is divided into three main geographic units, each unit running north to south: 1) the coastal region in the west, having undulating to hilly topography; 2) the mountain and hill region in the center; and 3) the eastern most Jordan-Arava Rift valley. In addition to the above, there are numerous dissecting valleys and several plateaus, especially in the southeastern part of the coastal region, and in the northeastern part of the mountain and hill region (Dan and Koyumdjisky, 1963).

The above mentioned geographic divisions are similar to the physiographic and lithologic units. Quaternary sediments, and to a small extent Pliocene alluvial and eolian sediments, form the parent materials for the soils in the valleys, plains, and plateaus. An exception is the plateaus of eastern Galilee. They are covered by large, Quaternary flows of basalt. Hard and soft calcareous rocks are the main parent materials in the mountain and hill region. In the coastal region, most of the soils are derived from sand dunes (Dan and Koyumdjisky, 1963).

The soils of the coastal regions are derived mainly from sandy sediments. In the Mediterranean climatic zone of the north, the soils are non-calcareous with a pronounced illuvial B horizon. In the southern coastal region, the soils are calcareous and a Bca or Cca horizon is present. The textural differences within the soil are less pronounced (Dan and Koyumdjisky, 1963).

The soils of the mountain and hill region are associated with hard limestone, dolomite and nari (a hard crust of calcium carbonate on chalky and marly rock). These soils are mostly shallow (30 to 60cm) and fine textured. The soils of the Mediterranean zone are noncalcareous. well structured and fine textured. In the semiarid and arid zones, the soils are calcareous and coarser textured (Dan and Koyumdjisky, 1963).

The soils of the valleys, plains and plateaus vary markedly with climate. In northern Israel, the soils developed from Quaternary alluvial clay sediments or from late Pliocene basaltic rocks. In the south, the soils developed from Quaternary silty sediments, and in the extreme south, the soils were derived form Quaternary gravelly deposits. In the Mediterranean climate of the north, the soils are fine textured and crack precluding definite horizons. In the semiarid zone and southwards, the soils become more silty. A calcium carbonate accumulation occurs in the soil. This calcareous horizon becomes shallower as the climate becomes more arid. The relative coarseness of these soils prevents churning and allows horizon differentiation. This horizon differentiation is in the form of a Bca horizon at depths of 1 to 2 meters. In the northern part of the semiarid zone, the soils are still fine textured. In the part of the arid zone which receives more than 100mm rainfall, most of the soils are derived from loess. They have a fine sandy loam to silt loam surface and a finer textured subsoil. North of the 250mm isohyetal there is no appreciable salt accumulation found in the soil. South of the 250mm isohyetal, there appears a pronounced sa (salt accumulation) horizon, in addition to a shallow ca (calcium carbonate) horizon. In the extreme arid zone, most of the soils are confined to flat gravel plains. These soils, called hammadas, have a gravelly cover (desert pavement), a gray, loamy, vesicular horizon about 4 to 8 cm thick underneath the gravel layer, and a somewhat finer textured, single grained and very saline horizon, about 10 to 30 cm thick above the parent material. Most of the coarse stony sediments consist of hard limestone, flint, and chalk (Dan and Koyumdjisky, 1963).

The Negev

The Negev, which occupies more than one half of the area of Israel, is the largest dry area in the country (Ravikovitch, 1953). The Negev can be divided into several subregions as shown in Figure 1 (Yaalon and Dan, 1974). The basin around Beersheba is an undulating, gently rolling depositional surface which slopes from an elevation of 550 meters at Arad northwestward towards the Mediterranean coastal sand ridges. Quaternary eolian loess and sand deposits of variable thickness (up to 15 m) cover about 80 percent of the area. The remaining area has Tertiary limestone and marl outcroppings. In many, the loess has been redeposited by streams and by Recent gully erosion. A large field of shifting sands is found in the southwestern part of the basin (Yaalon and Ginzbourg, 1966).

The climate of the Negev in general is quite variable. Rainfall ranges from less than 65 mm per year to about 350 mm. The borders of the Negev vary above and below the above extremes. The winters are mild with 10 to 20C mean January temperatures with occasional rainfall. The summers are rainless and warm with 25 to 28C mean August temperatures. The area around Beersheba has an Ac 23 climate type according to Meigs (1953b). Type Ac23 can be interpreted as follows: A--Arid, c--winter precipitation, 2--10-20C mean temperature in coldest month, 3--20-30C temperature in the warmest month. Beersheba has about 30 rainy days from November to March. The mean temperature is 20C and the mean January temperature is 12.2C while the mean August temperature is 26.7C. Daily mean annual wind intensity is 10 km/h (17 km/h at 2 pm), or about the same as other lowland areas of Israel. In 12 percent of the wind measurements, the intensity exceeds 20 km/h, and only in 1 percent of all cases exceeds 35 km/h (Yaalon and Ginzbourg, 1966). The mean annual precipitation for Beersheba is 198 mm and the adjusted potential evapotranspiration is 1,050 mm. The Moisture Index is -48.7 (Meigs, 1953b). Meigs (1953b) used the Thornthwaite moisture index of -20 as the outer limit for semiarid climates, a -40 for the outer limit of arid climates and a -57 as the outer limit for extreme arid climates.

The climatic type Ac23 of Meigs (1953b) is similar to that of the southwestern part of the United States. The Los Angeles and surrounding portions of southern California belong to the Northern Negev. The summer air temperatures of the coastal plain from Tel-Aviv to Gaza averages 25 to 26C while the summer temperature of the Los Angeles and San Diego, California, area averages only 20 to 22C. The winter temperatures for all compared areas is about 13C. To find a close analogue to the summer conditions of the Israel coastal plain in southern California, it is necessary to go inland at least 80 km.

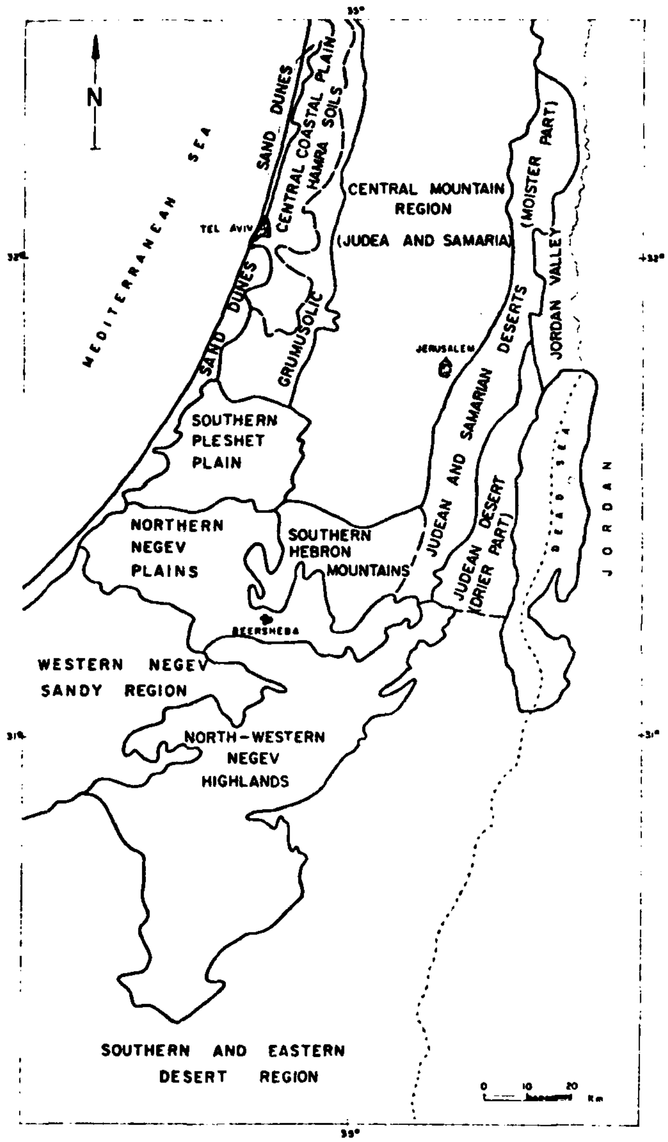

Figure 1. Subregions of the semidesert and desert fringe areas of Israel.

An area of interest adjacent to the Beersheba basin is the central Negev Highlands. This area covers nearly 2,000 sq. km. in the southern desert of Israel. This area receives more rain than the regions south and east because it faces westward into the path of cloud bearing winds (Hillel and Tadmor, 1962).

The area consists of a series of parallel anticlinal folds with a northeast-southwest axis. The outcrops are mainly of upper-Cretaceous dolomitic limestone, and of Tertiary chalk, flint and limestone. Most of the region drains into the Dead Sea through Wadi Zin and its tributaries. Some parts are drained into the Mediterranean by upper tributaries of the Habsor and Mitsrayim Wadis. The altitude rises from about 300 m in the north to 1,000 m in the south (Hillel and Tadmor, 1962).

Mean temperatures for July and August are about 25C. The mean temperatures for January and February are about 10 to 11C. The mean daily range of temperature is about 15 to 20C. Summer maximum temperatures rarely exceed 40C. Winter minimum temperatures drop to 4C and frost at ground surface is common. Annual rainfall varies from 40 to 150 mm with a mean of 100 mm occurring in 20 to 30 days, mainly between November and April. Relative humidity averages 50 to 60 percent, but drops considerably in early afternoon. Dew occurs 150 to 200 nights of the year with a total of 20 to 30 mm/yr. Prevailing winds are mainly southwesterly to northwesterly. Dust storms are frequent (Hillel and Tadmor, 1962).

The Central Negev Highlands can be divided into four distinct plant habitats which reflect the dominant soils. These are: 1) rocky slopes, 2) loessial plains, 3) wadi beds, and 4) sands.

SOILS OF ISRAEL--GENERAL

Loess

Most of the soils of Israel are covered with varying amounts of loess or affected by airborne dust (Yaalon and Ginzbourg, 1966; Ginzbour and Yaalon, 1963; Dan and Yaalon, 1964 and 1966; Yaalon and Ganor, 1973). Thirty to forty percent of the soil material in the uplands of limestone associated soils, where fluvial contamination can be excluded, is of eolian origin. There is a similar proportion in the basalt-derived soils (Yaalon and Ganor, 1973). The soils of the Negev are of eolian origin; however, they differ greatly from soils found in adjacent but similar climatic regions (Ravikovitch, 1953). They are marked by a much thicker accumulation of eolian sediments (loess).

The loess of the Negev in Israel has been mostly transported from the Sinai. The source area of the loess is postulated to be the wadi deposits of the wadi El Arish watershed which drains a large part of the Sinai. The wide wadis receive fine-grained sediments after the occasional floods. These sediments become the source of the loess. The moderate winds are unable to remove the fine earth from the stable desert pavement surfaces or rocky slopes of the adjacent uplands. The fine earth must first be washed off the hills to become a loess source (Yaalon and Ganor, 1973).

Mineralogical and faunal evidence has been used to determine that the weathering residues of limestones of mainly Senorian and Eocene age, which are widely exposed in the southern desert, supplied the primary material for the loess in the Beersheba Basin. A significant clue is the rarity of augite, which is an important mineral in recent coastal sands brought to the eastern Mediterranean coast by offshore currents, and which is also widespread in the detritus derived from basalts in the northern part of Israel. The absence of titanite and of other minerals characteristic of the Sinai magmatic and metamorphic province is also of note. Sands of the Nubian facies contain only zircon, tourmaline and rutile. This facies, therefore, could not have supplied much material to the dust. Analysis of the dust storms from Egypt also indicate that the dust particles have not been carried over a great distance (Yaalon and Ginzourg, 1966).

The particle size of dust transported long distances is usually somewhat finer (1 to 20 microns) than loess that traveled short distances. The eolian particles in the north part of Israel, therefore, are somewhat finer than the loess of the Beersheba Basin. The average composition of the many dust samples collected all over Israel shows montmorillonite as the major clay mineral with some kaolinite and quartz. Carbonates dominate the silt fraction. In the more humid north, leaching is sufficiently rapid to dissolve and leach out the carbonates, leaving only the noncarbonate fraction as net addition in the soils. Carbonates are generally a characteristic component of dusts and loess in Israel. In the more arid regions of Israel, where the rate of leaching of carbonates is not sufficient for complete removal, the redistribution of the carbonates is often the major process of soil development (Yaalon and Ganor, 1973).

The presence of calcium carbonate nodules and carbonate horizons in loessial soils has been used as an indication of a slight north and south shift of the semiarid belt during the Pleistocene (Yaalon and Ganor, 1973). A complex of loess-covered paleosols (old soils) on the fringe of the desert is found in Israel (Dan and Yaalon, 1971), where, over a long period of time, eolian deposition has been continuous, but with a slightly varying rate of deposition. Because of the continuous eolian growth of the soil and simultaneous soil formation, pedogenic soil boundaries are not sharp (Yaalon and Ganor, 1973).

Soils of the Negev

The soils of the Negev are quite variable, ranging from thick loessial deposits in the north to gravelly, alluvial plains in the south. The soils of the Negev are discussed as follows in three divisions as shown in Figure 1: the northern Negev plains, the northwestern Negev Highlands, and the southern and eastern desert region.

The northern Negev plains

The following is summarized from Yaalon and Dan (1974). Loessial deposits are most widespread in this rolling and undulating region. The loess derived soils which cover the slightly sloping upland area exhibit well differentiated profiles with textural B and calcic horizons, often overlying a more clayey or other buried horizons. There does not exist any sharp transition to the underlying layers and the profiles are typical cumulative surfaces. Soils found in depressions and floodplains lack definite genetic horizons and resemble their loessial parent material.

Not all the sloping upland areas are covered by loess-derived soils. South-facing slopes in the more arid parts of the region are often not covered by loess, which mainly accumulates on north-facing slopes.

The texture and the nature of the calcic horizon varies according to locality and position. The texture of the loessial-derived soils becomes gradually finer towards the northern part of the region, especially when considering the upland soils. The carbonate content increases slightly towards the east and the south, and nodules in the calcic horizons are a common feature, their development greatly influenced by the nature of the matrix.

The texture of soils in the depressions and younger terraces may range from fine sandy loam to silt loam. Carbonate content is usually higher in finer-textured soils than in the sandy ones. Most of these younger soils reveal little profile development, though in the higher terraces of Nahal Besor calcic horizons do occur.

The loessial soils to the north of the inland dunes are coarser textured due to the incorporation of some blown sand. Their carbonate content is lower but a gypsic horizon develops at depth. The wadi bed of Nahal Besor acts as a barrier for the further advancement of the sand northwards.

The northwestern part of the Negev Highlands

Loessial deposits cover most of the valleys. In many places, especially along small tributary valleys, they interfinger with gravelly deposits. Most of these sediments lack any pedogenic profile differentiation; any textural variations found are essentially due to fluviatile sedimentation. Carbonate content varies according to rock characteristics in the surrounding area. The soils are highly calcareous in areas which are surrounded by chalky and marly rocks. The carbonate content is much lower in areas of dolomitic and limestone rocks. In east-west oriented valleys there is a noticeably larger accumulation of loessial material on the north facing slopes than on the south facing ones (Yaalon and Dan, 1974).

Older terraces and large plateaus are characterized by well-differentiated profiles with definite calcic and gypsic horizons and they were classified as loessial Serozems (Typic Haplargids). Those found along the valley terraces are of alluvial origin, as indicated by interbedded stony and gravelly layers. The carbonate content of the loessial Serozems (Typic Haplargids) varies according to locality and surrounding rocks. The loessial Serozems (Typic Haplargids) on the plateaus are more homogeneous, and contain no gravelly or other sedimentary layers (Yaalon and Dan, 1974).

Dan, Moshe and Alperovitch (1973) have studied extensively three soils formed from loess which differ from each other in many respects. The location of the study is in Sede Zin which is located about 30 km south of Beersheba. The soils studied are in map unit R at Sede Boqer (see figure 5). The soils of this study are shown in Figure 2 and in Tables 1 through 5. Sede Zin is found in the syncline between the anticlinal Haluqim and Hathira mountain ridges. Cenomonian and Turonian limestones and dolomites cover most of these anticlinal ridges. Menuha chalk and Mishash flint were found along the mountain border. The sediments of the syncline consist of Paleocene and Eocene marls and chalk, which are covered, in many places, by Neogene gravel and conglomerates. The Neogene gravel is found also in the Sede Boqer plain itself. Pleistocene loessial sediments cover most of the Neogene gravel and conglomerates in Sede Zin and it was assumed that most of this loess was of eolian origin (Dan, Moshe and Alperovitch, 1973).

The differences of the soils in the Sede Zin study may be related to the time factor and the age of the parent material. The oldest soil (Table 1, 2 and 3), a Typic Haplargid (typical clay loam loessial Serozem), covers the highest parts of Sede Zin. This is a well-differentiated soil with a textural B horizon and a calcic horizon. The deeper soil layers are very saline. Two horizons of secondary gypsum were found. This feature may be related to the polygenetic character of the soil. The deeper cs horizon was formed in the past when the area enjoyed a somewhat more humid climate, while the higher cs horizon is being formed at present due to the extremely arid climate. The second soil (Table 4), a Typic Camborthid (sandyloam loessial Serozem), covers the lower parts of Sede Zin. The profile differentiation is restricted mainly to some redeposition of lime, gypsum and salts in the deeper soil layers. The soil is less saline than the finer textured loessial Serozem (Typic Haplargid) and only one gypsum horizon was revealed. This gypsum horizon may be correlated with the first, upper, gypsum horizon of the fine textured loessial Serozem (Typic Haplargid). This soil is young and, since it does not reveal any polygenetic characteristics, has been developed only during the recent cycle of dry climate. The youngest soil (Table 5), the Xerofluvent (alluvial loess), is confined to small depressions in the plain. This is a young, nonsaline soil that does not reveal any profile differentiation.

Hillel and Tadmor (1962) have described the soils of the Central Negev Highlands, which, in part. are included in the northwestern part of the Negev

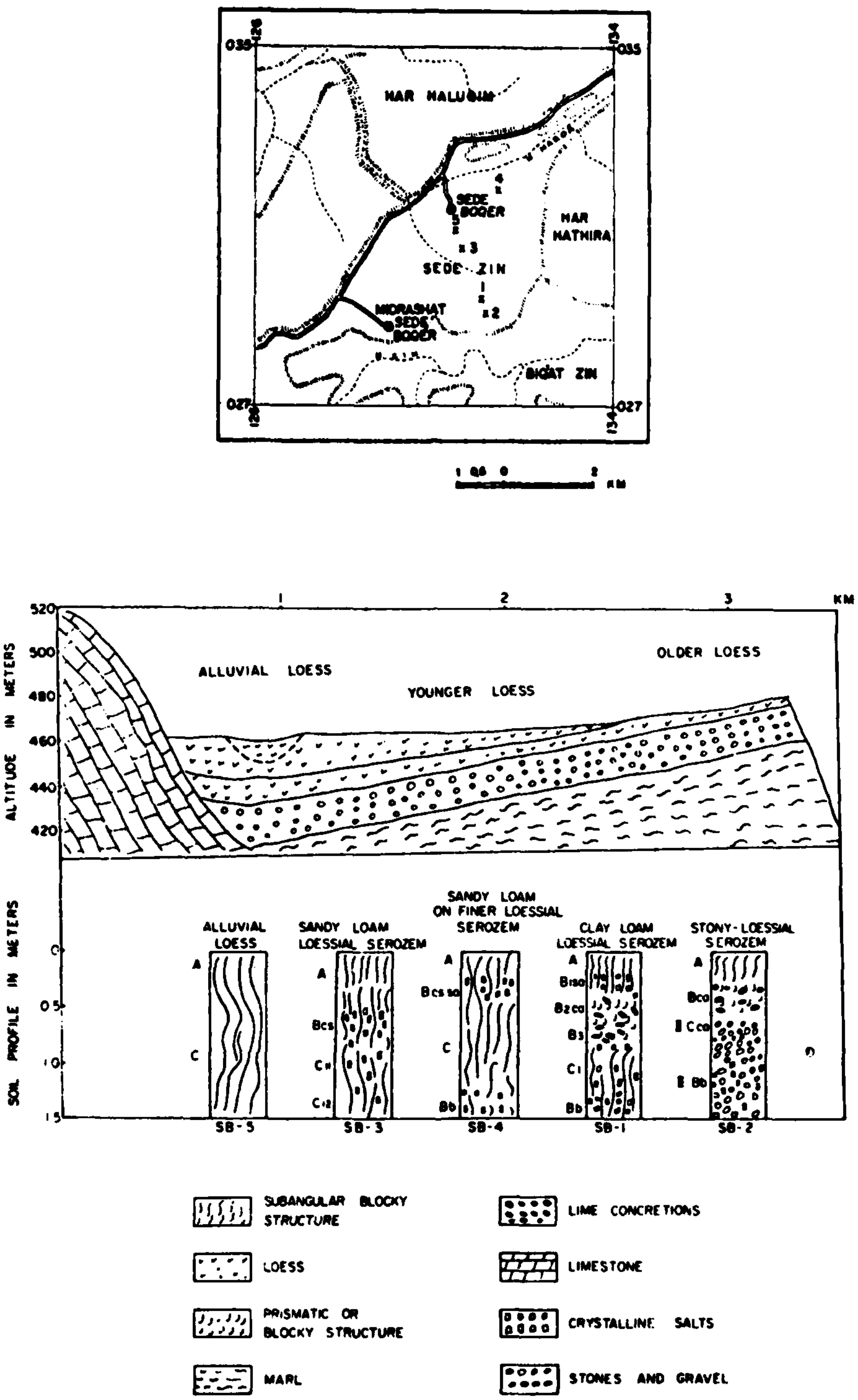

Figure 2. Schematic cross section of the Sede Zin plain from northwest to southeast.

Table 1. Soils of the Sede Zin plain in the Negev, Israel (Dan et al, 1973)

PROFILE: S.B.1. Clay Loam Loessial Serozem (Typic Haplargid)
LOCATION: 2 km south of Sede Boger at coordinate 1310/0294
SITE: Upper part of a broad plain that is covered by loessial sediments. The slope reaches only 1%.

PROFILE DESCRIPTION:

A	0-22cm. Very pale brown (10YR7/3) dry, light yellowish brown (10YR6/4) moist loam; strong, medium to fine subangular blocky structure; soft in upper part and hard in lower part; nonsticky but plastic; smooth, clear boundary.
B1sa	22-35cm. Similar layer with many small (up to 1 mm) white mottles of crystalline salt and gypsum; smooth, clear boundary.
B2ca	35-70cm. Brown (7.5YR4.5/4) dry, dark brown (7.5YR4/4) moist silty clay loam with many (50% by volume) medium to large (2 cm or more in diameter) white lime ($CaCO_3$) mottles, most of which are elongated vertically; some small black mottles were also visible; medium blocky to prismatic, breaking into strong medium to fine blocky structure; clear cutans cover the aggregate surfaces; very hard, slightly sticky and plastic; smooth, clear gradual boundary.
B3	70-82cm. Strong brown (7.5YR 5/6) dry and moist silty clay loam with few white lime spots and very few small black mottles; medium blocky breaking into strong fine blocky structure; clear cutans on aggregates; hard, nonsticky but plastic; clear to gradual boundary.
C1	82-132cm. Light yellowish brown (10YR 6/4) dry, yellowish brown (10YR5/4) moist silty clay loam with few salt crystals; massive to weak subangular blocky strucutre; hard, nonsticky but plastic; smooth, clear boundary.
Bb	132-165cm. Reddish yellow to yellowish brown (6YR 5/6) dry and moist loam to clay loam with many (about 50% by volume) lime spots and many gypsum crystals mostly arranged in thick mycelia; moderate fine blocky to subangular blocky structures; faint cutans on aggregates; very hard, sticky and plastic; the same layer continues to greater depths.

Table 1. (Cont.) Soils of the Sede Zin plain in the Negev, Israel
Profile S.B.1.

		Particle Size Fraction					Exchangeable Cations				
Horizon	Depth	Clay	Silt	Fine Sand	Coarse Sand	CEC	Ca	Mg	K	Na	ESP
	cm	%				meq/100g					%
A1	0-10	21.8	36.3	39.6	2.3	18.6	11.1	2.3	0.9	4.3	23.3
A3	10-22	25.2	41.1	31.9	1.9	20.2	7.4	3.6	0.7	8.4	42.8
B1sa	22-35	25.2	46.8	26.4	1.6	21.6	8.6	5.6	0.2	7.2	33.2
B2ca	35-70	33.0	43.4	22.0	1.6	22.9	9.5	5.4	0.6	7.4	32.4
B3	70-82	35.4	39.1	21.1	4.4	23.3	6.5	8.5	0.6	7.8	33.2
C11	82-105	33.6	40.7	21.8	3.9	25.0	10.2	6.3	0.6	8.0	31.8
C12	105-132	32.9	41.6	22.0	3.5	26.2	10.6	7.3	0.6	7.6	29.1
Bb	132-165	29.6	40.9	19.5	10.4	24.0	7.2	8.4	0.5	8.0	33.3

			Soluble Salts								
Horizon	pH	EC	Na	k	Ca	Mg	Cl	HCO3	SO4	CaCO3	CaSO4
		mmho/cm	meq/100g							%	
A1	8.4	1.4	0.7	0.004	----	0.08	0.3	0.21	0.28	24.8	---
A3	8.2	9.6	4.7	0.004	0.33	0.08	4.0	0.16	1.00	23.6	---
B1sa	7.7	41.5	20.1	0.013	6.03	4.16	24.5	0.11	5.67	23.9	1.1
B2ca	7.7	33.2	16.7	0.012	4.39	3.49	22.1	0.12	2.40	35.7	---
B3	7.7	33.2	15.8	0.011	4.18	3.30	21.7	0.09	1.53	33.4	---
C11	7.8	28.8	15.8	0.009	4.06	3.10	22.0	0.11	0.87	27.7	---
C12	7.8	30.2	15.1	0.008	4.90	3.23	21.4	0.09	1.80	30.0	0.8
Bb	7.8	27.4	12.5	0.007	3.98	2.41	16.0	0.08	2.87	43.7	3.9

Table 2. Soils of the Sede Zin plain in the Negev, Israel (Dan et al, 1973)

PROFILE: S.B.2. Stony-Loessial Serozem (Typic Haplargid)
LOCATION: 100 m south of profile No. 1 and 2 km south of Sede Boqer, at coordinate 1311/0293
SITE: Upper part of a broad plain; most of the plain is covered by loess but on the edge the underlying stony sediments reach the surface. The slope reaches only 1%.

PROFILE DESCRIPTION:

A 0-24cm. Very pale brown (10YR7/3) dry, light yellowish brown (10YR6/4) moist, fine, calcareous loam; fine subangular blocky structure; soft, nonsticky but slightly plastic; smooth, clear boundary.

Bca 24-55cm. Light yellowish brown (10YR6/4) dry, yellowish brown (10YR5/4) moist silty clay loam with many (about 50% by volume) large lime spots (2 cm and more), mostly arranged vertically; medium prismatic to blocky breaking into fine blocky structure; clear cutans on aggregates; very hard, slightly sticky and very plastic; abrupt, wavy boundary.

IICca 55-80cm. Very pale brown (10YR8/3 dry, 10YR7/3 moist) gravelly (40% gravel) massive loam; most of the layer consists of soft lime with pockets (30% by volume) of more brownish soil; hard, nonsticky but slightly plastic; gradual boundary.

IIBbsa 80-114cm. Pink (7.5YR7/4) dry, reddish yellow (7.5YR6/6) moist very gravelly (70% gravel) loam with many (about 10%) mycelia of salt and gypsum crystals and few lime concretions; massive, slightly sticky and plastic.

		Particle Size Fraction					Exchangeable Cations				
				Fine	Coarse						
Horizon	Depth	Clay	Silt	Sand	Sand	CEC	Ca	Mg	K	Na	ESP
	cm	%				meq/100g					%
A	0-24	20.8	38.4	37.5	3.3	16.6	6.7	2.4	0.8	6.7	40.3
Bca	24-55	28.3	45.9	18.2	7.6	17.6	3.5	4.6	0.5	9.0	51.2
IICca	55-80	13.0	32.7	19.4	34.9	11.4	4.0	2.5	0.4	4.5	39.1
IIBbsa	80-96	22.4	39.5	16.3	21.8	14.6	4.8	3.2	0.4	6.2	42.4
IIBbsa	96-114	22.0	39.6	17.2	21.2	13.6	8.0	6.8	0.4	5.6	41.8

			Soluble Salts								
Horizon	pH	EC	Na	k	Ca	Mg	Cl	HCO3	SO4	CaCO3	CaSO4
		mmho/cm	meq/100g							%	
A	8.0	12.6	5.2	0.010	0.96	0.46	5.3	0.084	1.24	31.8	0.03
Bca	7.5	13.9	17.6	0.006	9.70	8.22	29.7	0.074	5.70	45.7	0.31
IICca	7.7	29.5	11.8	0.007	5.80	3.41	17.9	0.093	3.00	69.0	1.24
IIBbsa	7.8	26.3	12.6	0.006	4.68	3.35	19.2	0.087	1.37	58.8	0.05
IIBbsa	7.9	22.6	11.3	0.009	5.08	2.75	14.9	0.099	4.16	59.3	6.10

Table 3. Soils of the Sede Zin Plain in the Negev, Israel (Dan et al, 1973)

PROFILE: S.B.3. Sandy Loam Loessial Serozem (Typic Haplargid)
LOCATION: 1 km south of Sede Boqer, at coordinate 1306/0305
SITE: Broad plain covered by loessial sediments. The whole area has a very slight northwestern slope of 0-1%.

PROFILE DESCRIPTION:

A 0-55cm. Very pale brown (10YR7/3) dry, light yellowish brown (10YR6/4) moist, fine sandy loam; massive tc weak subangular blocky structure; soft, nonsticky but slightly plastic; clear boundary.

Bcssa 55-80 cm. Similar to above layer, with many salt and gypsum crystals mostly arranged vertically; weak medium blocky to subangular blocky structure; hard, in dry conditions; sharp boundary.

C11 80-130cm. Very pale brown (10YR7/3) dry, light yellowish brown (10YR6/4) moist fine sandy loam with very few salt and gypsum crystals; massive, soft, nonsticky but slightly plastic; gradual boundary.

C12 130-160cm. Similar layer without salt and gypsum crystals.

Horizon	Depth	Particle Size Fraction: Clay	Silt	Fine Sand	Coarse Sand	CEC	Exchangeable Cations: Ca	Mg	K	Na	ESP
	cm	%				meq/100g					%
A1	0-30	6.4	34.2	57.9	1.4	12.4	7.2	1.9	1.0	2.3	18.5
A3	30-55	11.5	52.5	35.6	0.4	15.6	7.4	3.9	0.7	3.7	23.4
Bcs	55-80	14.9	60.2	24.9	---	18.7	3.6	9.7	0.6	4.8	25.5
C11	80-130	11.2	48.4	40.5	---	16.1	5.9	3.7	0.4	6.2	38.2
C12	130-160	10.7	46.8	41.6	1.0	13.4	3.1	3.2	0.4	6.7	49.7

Horizon	pH	EC	Soluble Salts: Na	k	Ca	Mg	Cl	HCO3	SO4	CaCO3	CaSO4
		mmho/cm	meq/100g							%	
A1	8.2	3.4	0.8	0.010	0.30	0.13	0.82	0.066	0.35	21.4	0.02
A3	7.7	16.6	4.3	0.012	2.65	1.30	7.71	0.076	0.48	21.6	0.01
Bcs	7.7	22.6	6.5	0.011	3.80	1.98	10.40	0.073	1.81	21.8	1.29
C11	7.9	21.3	7.1	0.009	2.17	1.71	8.58	0.063	2.34	22.9	0.30
C12	8.0	23.5	8.1	0.009	1.88	1.71	8.35	0.063	3.28	22.4	0.43

Table 4. Soils of the Sede Zin plain in the Negev, Israel (Dan et al, 1973)

PROFILE: S.B.4. Landy Loam Loessial Serozem (Typic Camborthid), on Finer Textured Loessial Serozem.
LOCATION: 1 km. nortneast of Sede Boqer at coordinate 1315/0318
SITE: Broad plain covered by loessial sediments. The whole area has a very slight (1%) western slope.

PROFILE DESCRIPTION:

A 0-22cm. Very pale brown (10YR7/4) dry, light yellowish brown to yellowish brown (10YR5.5/4) moist, very fine sandy loam to silt loam; massive to weak subangular blocky structure; slightly hard, non-sticky but plastic; gradual boundary.

Bcssa 22-52cm. Very pale brown (10YR7/4) dry, light yellowish brown to yellowish brown (10YR5.5/4) moist loam with some white lime mottles and quite a lot of salt and gypsum crystals; subangular blocky structure; slightly hard, nonsticky but plastic; gradual boundary.

C 52-126cm. Very pale brown (10YR7/4) dry, light yellowish brown (10YR6/4) moist, massive very fine sandy loam to silt loam; nonsticky but slightly plastic; clear boundary.

Bb 126-186cm. Light yellowish brown (10YR6/4) dry, yellowish brown (10YR5/4) moist silt loam with many lime spots and many gypsum and salt crystals; massive parting into subangular blocky structure; very hard, slightly sticky and plastic; same layer continues at greater depths.

Horizon	Depth	Particle Size Fraction Clay	Silt	Fine Sand	Coarse Sand	CEC	Exchangeable Cations Ca	Mg	K	Na	ESP
	cm	%				meq/100g					%
A	0-22	22.9	56.6	20.2	0.3	15.1	3.7	5.4	0.2	5.9	38.9
Bsa	22-52	18.1	63.6	18.0	0.2	16.1	2.3	7.1	0.1	6.6	41.1
C	52-126	13.3	63.7	23.0	0.1	15.1	3.7	5.6	0.1	5.7	37.8
Bb	126-186	19.4	54.1	26.5	---	13.9	2.9	5.4	0.1	5.5	39.4

Horizon	pH	EC	Soluble Salts Na	k	Ca	Mg	Cl	HCO3	SO4	CaCO3	CaSO4
		mmho/cm	meq/100g							%	
A	7.9	2.6	1.20	0.006	0.10	0.05	0.92	0.19	0.21	24.3	----
Bsa	7.5	38.2	18.72	0.011	3.46	4.47	22.26	0.05	4.35	22.7	3.01
C	7.6	26.3	10.07	0.008	1.85	2.20	13.32	0.07	0.77	19.9	0.15
Bb	7.6	26.3	10.37	0.012	3.15	2.99	14.34	0.07	2.10	24.4	0.84

Table 5. Soils of the Sede Zin plain in the Negev, Israel (Dan et al, 1973)

PROFILE: S.B.5. Alluvial Loess (Xerofluvent)
LOCATION: About 1 km east of Sede Boger at coordinate 13058/03088
SITE: Central strip of a small depression 30-50 m wide in the lower part of Sede Zin.

PROFILE DESCRIPTION:

A 0-30cm. Very pale brown (10YR7.5/3) dry, light yellowish brown (10YR6/4) moist very fine sandyloam; calcareous, massive, soft, non-sticky but slightly plastic; gradual boundary.

C 30-150cm. Light yellowish brown (10YR6/4) dry, yellowish brown (10YR5/4) moist very fine sandyloam; calcareous, massive to weak subangular blocky structure; hard, nonsticky but slightly plastic; the same soil continues to greater depths.

		Particle Size Fraction					Exchangeable Cations				
Horizon	Depth	Clay	Silt	Fine Sand	Coarse Sand	CEC	Ca	Mg	K	Na	ESP
	cm	%				meq/100g					%
A	0-30	14.4	38.5	45.9	1.2	11.7	6.2	5.0	0.2	0.4	3.2
C11	30-60	16.8	46.0	36.2	1.0	11.8	6.0	5.0	0.1	0.6	5.4
C12	60-90	15.6	48.6	33.6	2.2	13.1	7.3	4.9	0.1	0.9	6.5
C13	90-120	15.8	59.0	25.1	---	13.1	6.8	4.9	0.1	1.3	10.1
C14	120-150	17.4	55.8	26.6	0.2	13.2	5.5	5.5	0.1	2.2	16.3

			Soluble Salts								
Horizon	pH	EC	Na	k	Ca	Mg	Cl	HCO3	SO4	CaCO3	CaSO4
		mmho/cm	meq/100g							%	
A	7.8	0.66	0.09	0.02	0.14	0.04	0.12	0.11	0.06	21.5	----
C11	7.9	0.40	0.08	0.005	0.08	0.05	0.06	0.12	0.03	24.2	----
C12	7.9	0.46	0.11	0.003	0.07	0.05	0.09	0.11	0.03	23.3	----
C13	7.9	1.51	0.45	0.003	0.14	0.09	0.43	0.11	0.15	25.9	----
C14	7.8	2.40	0.81	0.003	0.15	0.15	0.86	0.10	0.17	19.9	----

Highlands of Yaalon and Dan (1974). Hillel and Tadmor (1962) described the soils in terms of four distinct habitats: rocky slopes, loessial plains, wadi beds and sands. Average properties of these soils are shown in Table 6.

The Rocky Slopes occupy 80 to 85 percent of the area. Soil cover is shallow (0-80cm). On the limestone hills the bedrock is exposed in many places and soil material is largely confined to pockets and cracks among the rocks. Soils overlying soft chalk have fewer stones and are generally deeper. Lime content increases with depth to 40-50%. Excess soluble salts have apparently been leached by rain from the upper soil layer, but below it are saline concentrations of 1-3%. Gypsum is present in small amounts. The pH varies from 7.5 to 8.5.

The Loessial Plains are mainly near watershed divides and in the wider synclinal valleys. The soils are eolian loess of heaver texture and loess-like alluvium of coarser texture along the main water courses. They are deep and uniform. Salinity below the depth of rainfall penetration may reach 2% or even more. Gypsum is present in small amounts. The pH varies from 7.5 to 8.5.

The Wadi Beds occupy about 3 to 5% of the total area, and occur in narrow and winding bands. Several types are recognized: 1) large, or regional, wadis, generally with gravelly beds; 2) synclinal valley-wadis, generally loessial; 3) small tributary mountain-wadis, generally with mixed gravel and loess beds; and 4) wide and shallow depressions in loessial plains. The gravelly wadi beds contain 70 to 100% coarse to fine gravel. Salinity is negligible. Considerable quantities of water seep into the gravel during flash floods, and in certain locations perched water tables are formed. The loessial wadis generally occur in the central valleys as broad, shallow and gently-grading (1/2 to 1%) coarses. The loess-like soil is frequently interlayered with gravelly horizons. Salinity is low.

The Tureibe Sands occupy a large synclinal valley in the northeastern part of the region, and are apparently of continental Tertiary formation. The undulating semistable dunes are spotted with patches of a reddish, sandy soil. The depth of these sands is generally greater than one meter. The sand contains lime, and is relatively free of excess soluble salts.

<u>The southern and eastern desert region</u>

This region has large areas of soils which are gravelly or are covered with a gravelly desert pavement. The few loess-like deposits found in this strongly dissected region include various silty, well-bedded alluvial sediments in the dry playas and in the wide flat wadi beds (Yaalon and Dan, 1974). The various layers may differ one from the other in particle size distribution and carbonate content. They resemble the fine weathering product of the soils and rocks found in the watershed and the A horizon material of the adjoining soils. In the southern Negev plain, which is surrounded by carbonate rocks and calcareous sediments, the silty loess-like deposits are highly calcareous. In the southern part of the Arava valley these deposits are less calcareous because of the local predominance of sandstones and igneous rocks (Yaalon and Dan, 1974).

Similar silty loess-like sediments are found around shrubs or nearly flat wadi-beds at the transition area to the deep loessial deposits, and in

Table 6. Soil physical properties representative of the Central Negev Highlands, Israel (Hillel and Tadmor, 1962)

Site	Mechanical Composition of Soil Gravel	Sand	Silt	Clay	Bulk Density	$CaCO_3$	Total Soluble Salts
	%				g/cc	%	
Rocky Slope	75	40	42	18	2.0	40.5	0.77
Loessial Plain	--	30	45	25	1.4	23.7	1.44
Loessial Wadi	Var.	35	43	22	1.4	26.2	0.10
Tureibe Sand	--	88	7	5	1.6	5.1	0.09

some places along the large wadis where tamarix and other plants cover the area. Occasionally some dusty material accumulates near tamarix shrubs, forming a small hill around the plant. Fine loessial material has also accumulated near springs along the Arava valley. Small patches around these springs are covered by a dense vegetation and eventually the area becomes somewhat elevated. The soils of these silty patches differ from the typical soils of the region. They contain a high percentage of humus and are usually stoneless. The texture is loamy and the carbonate content is moderate (Yaalon and Dan, 1974).

Chemical Properties of Israel Soils

Banin and Amiel (1969) did a correlative study of the chemical properties of a group of representative soils of Israel. Data on the chemical and physical properties, i.e., cation exchange capacity, organic matter content, $CaCO_3$ content, clay, silt and sand percentages, moisture content at the hygroscopic, 15 atm. and 1/3 atm., and saturated paste states and specific surface area, of a group of soils were subjected to statistical analysis in order to determine the correlation between pairs of properties, and to formulate quantitative regression equations for the properties that are significantly correlated.

The clay fraction exchange capacity is relatively high and amounts to 70 ± 5 meq./100g, indicating that the montmorillonitic group is probably prevailing in the clay fraction. This finding is in agreement with direct mineralogical determinations done on some of the soils and is also typical for soils of arid regions (Banin and Amiel, 1969).

Organic matter exchange capacity is 300 ± 72 meq/100g but the organic matter content is low. The organic matter content is probably affected by properties of the soil environment, mainly the climatic conditions, more than by the matrix properties of the soil. On the other hand, since the organic matter content is small, it affects to a very limited extent the physical and chemical properties of the soil (Banin and Amiel, 1969).

From a constant of a regression equation, it was estimated that the combined contribution of the silt and sand fraction to the cation exchange amounts to 5.1 ± 2.1 meq/100g. This is a relatively small exchange capacity and most of it probably resides in the silt fraction (Banin and Amiel, 1969).

The calcium carbonate content, a property which considerably affects the chemical state of several soil constituents, was found to be highly correlated with the silt percentage. Most of the soils analyzed contained significant quantities (10-40%) of calcium carbonate. The silt fraction is mainly composed of $CaCO_3$. From the regression equation, about 0.6% silt was contributed by 1% $CaCO_3$. Banin and Amiel (1969) postulated that the mineral stable size of $CaCO_3$ in the studied soils is in the silt fraction range of 2 to 20 microns equivalent diameter, and that the solubility rate of smaller particles and/or their surface area properties, render them unstable.

Salt presence is significant in many soils of Israel. According to Yaalon (1964a), annual accretion is only a few kilograms per hectare. In the southern Negev, there is a good correlation between the age of the desert pavement soil and its salinity. Rainfall is insufficient to leach the salts. The only nonsaline areas are found in wadis and in small topographic depressions which receive whatever runoff there may be during occasional rains and floods. There is a characteristic differentiation and distribution with depth according to their relative mobility: Cl>SO4>HCO3. The position of the maximum concentration can be estimated from the effective precipitation and available moisture capacity (Yaalon, 1964b). In a study of the carbonates and soluble salts of dust samples in the Negev, Yaalon and Ginzbourg (1966) found the following distribution of ions: cations--Ca>Na>K>Mg; anions--SO4>Cl>HCO3. CaSO4 (gypsum) dominates the Negev samples.

Mineralogy of Israel Soils

The clay minerals in the soils may be either inherited directly from the parent material, more or less epigenetically altered, or produced by the process of chemical weathering in the soil (Yaalon, 1966). Soil formation in Israel seems to be primarily a process of accumulation of the clay materials included with the carbonates accompanied by some leaching of the lime (Singer, 1966). In Israel, eolian accretion of desert dust is an additional important modifying factor (Yaalon, 1966).

Dust samples, collected in the Negev, were characterized by Yaalon and Ginzbourg (1966). The coarse fraction was composed mainly of rounded quartz grains, limestone and shell fragments. A few feldspars, micas and dark ore minerals were also present. The usual composition of the clay mineral free fractions in the dust is 25 to 45% calcite, 10-20% quartz and 3-10% feldspars (Yaalon and Dan, 1974). The amount of clay minerals varies from 5 to over 20%. Montmorillonite and mixed layer minerals are dominant among the clay minerals, followed by kaolinite, and smaller amounts of illite and palygorskite. The relatively small variability in composition over large areas confirms its common origin from a desert source. A higher content of quartz (e.g.,in Beersheba), feldspars (e.g.,in Elat) or dolomite (e.g.,in the Judean mountains) reflects the influence of local dust sources (Yaalon and Dan, 1974).

A characteristic assemblage of heavy minerals in dust (80% of those commonly present) includes opagues, hornblend, zircon, micas and epidote (Yaalon and Ginzbourg, 1966). The opagues are mostly irregularly shaped aggregates and are composed mainly of magnetite and ilmenite, often with limonitic coatings. The opagues generally comprise 40 to 60% of the heavy minerals present. Hornblende is mainly of the green and light green variety, with a few brown grains. They are generally angular to subangular. Hornblende generally makes up 20-40% of the heavy minerals. Zircons are mostly subrounded prismatic. Muscovite appears more common than biotite. Epidotes show a weathered appearance and often include alteration products. All other minerals occur in amounts less than 5%. Tourmaline is mostly of the brown variety. Staurolite, augite and olivine have a weathered appearance. Rutile and monazite are well rounded. Zircon and epidote are distinctly more abundant in the finer fractions, whereas micas are somewhat more common in the coarser fractions.

Table 7 and Figure 3 shows the composition of dust samples collected in southern Israel (Azmon, 1974).

Montmorillonite and Kaolinite are the most common clay minerals in the soils of Israel (Yaalon, 1966). Kaolinite is the stable clay mineral in the leached and decalcified soils of the Mediterranean climate. In an analysis of geologic sediments of the Negev area, Bentor (1963) found that kandites,

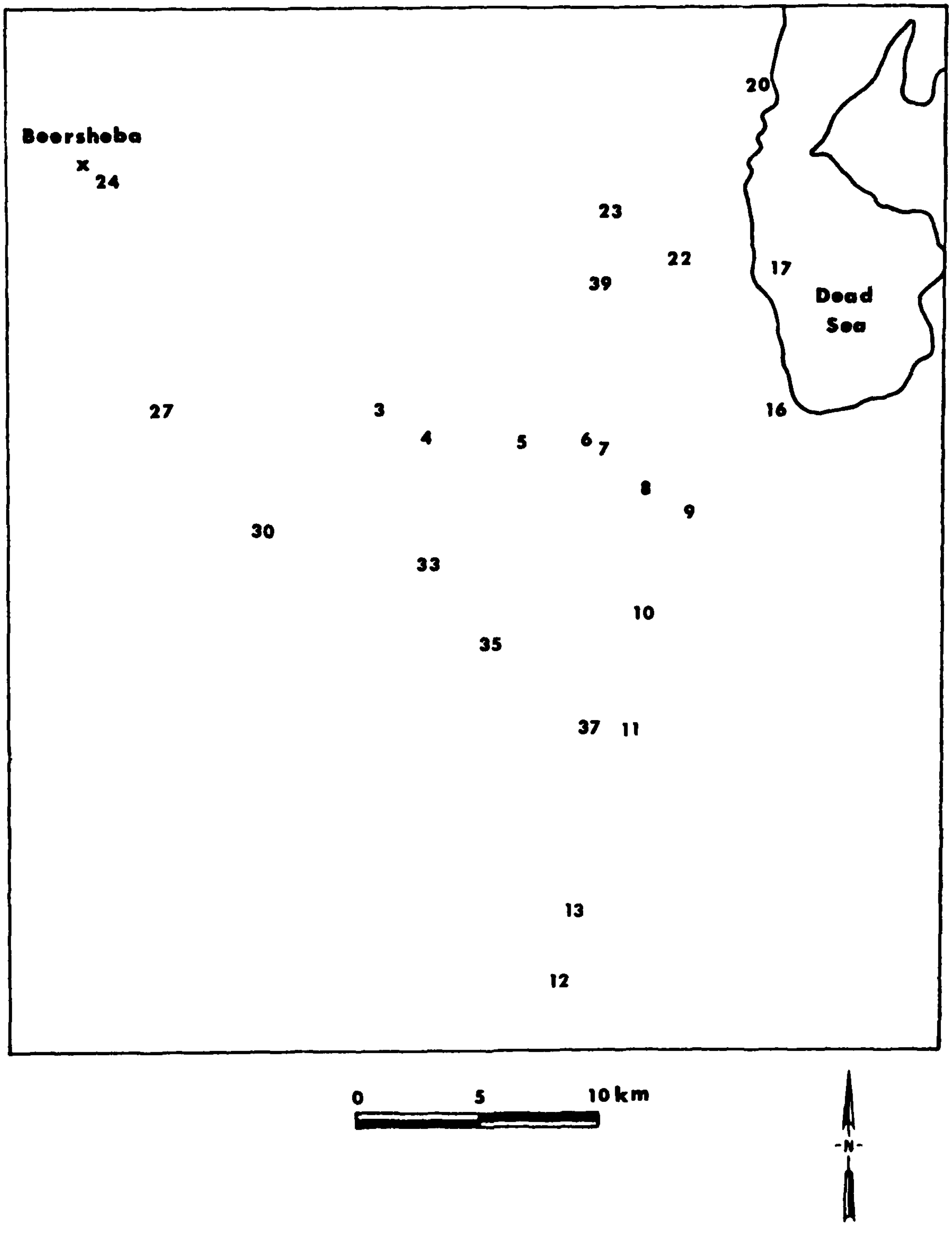

Figure 3. Location of dust samples collected in southern Israel (after Azmon, 1974).

Table 7. Mechanical and mineral composition of dust collected is southern Israel (Azmon, 1974)

Sample No.	>62 micron	<62 microns	Calcite	Quartz
	%			
3	98	2	95	5
4	63	37	96	4
5	93	7	82	18
6	77	23	93	7
7	38	62	97	3
8	71	29	89	11
9	88	12	98	2
10	81	19	97	3
11	96	4	82	18
12	66	34	99	1
13	86	14	94	6
16	91	9	99	1
17	98	2	97	3
20	96	4	94	6
22	79	21	95	5
23	77	23	95	5
24	73	27	78	22
27	91	9	84	16
30	67	33	92	8
33	85	15	96	4
35	95	5	89	11
37	78	22	95	5
39	77	23	89	11

smectites and illites to be by far the most common clay minerals. Interstratified material, mostly composed of smectite and illite, occurs frequently, and palygorskite is relatively widespread, mostly as an accessory mineral, but sometimes consituting a major component. Small amounts of hydrobiotite, vermiculite and sepiolite occur occasionally, but chlorite, elsewhere so common, was not found in appreciable amounts. In general, dioctahedral clay structures predominate; trioctahedral illites and smectites were identified in only a few samples (Bentor, 1963).

In southern Israel, the soil mineralogy reflects the mineralogy of the parent rock. Bentor (1963) classified the geologic sediments and identified the component minerals as follows: 1) Clays, sensu stricto, contain more than 90 percent clay minerals. They contain mainly illite and/or kandite, and never more than one third of smectite; 2) Sandy or silty clays contain macroscopically visible quartz grains. They are predominantly illitic and/ or kankite, and in most cases contain less than about 25% smectite; 3) Calcareous clays contain more than 10 percent calcium carbonate. They vary widely in composition, but have a definite tendency to avoid the kandites; 4) Dolomitic clays contain more than 10 percent calcium-magnesium carbonate. There is no generalization; 5) Phosphatic clays contain more than 5% P205. They contain about equal amounts of the three minerals: smectite, kaolinite and illite; 6) Bituminous clays contain more than 10 percent organic matter. They are mostly smectites; 7) Gypseous clays contain macroscopic crystals of gypsum, either in the hand specimen or in the outcrop. These may show any mineral, but frequently carry palygorskite; 8) Glauconitic clays contain macroscopic green to dark green, more or less rounded pellets, rich in potassium, ferrous and ferric iron, which are composed of randomly interstratified smectite and illite. They are mostly smectitic clays and are not associated with pure illite.

Table 8 shows the average mineral composition of a soil in the Negev (Barshad et al, 1956).

Surface Soil Structural Variation

The surface soils of Israel vary in consistance from soft to hard. The chemical and geomorphological characteristics of a hard and a soft loessial crust was described by Alperovitch and Dan (1973). The area they described is in the Sede Boqer plateau of the central Negev and is the same soil shown in Table 3. A very hard crust, which showed high ESP and pH values, was found at an eroded site. This site is similar, but eroded, to the soil in Table 3. The noneroded site (Table 3) had a softer crust and had lower values of ESP and pH. The very hard crust consisted of the saline layer of loessial Serozems (Typic Haplargids) whose upper surface was partially leached of soluble salts. The exchangeable sodium, however, was not leached and it was suggested that the resultant clogging of the top soil may be the cause of the hard crust formation (Alprovitch and Dan, 1973).

Vesicular structure is typical of the Gypsiorthids and Camborthids of the Negev and Sinai, which are covered by a typical desert pavement (Evenari et al, 1974). The vesicular layer is 1-3 cm thick, overlaying a fine, powdery, grayish to reddish, highly saline silt loam. On the surface of the Gypsiorthids and Camborthids, between the stones of the desert pavement, the foamy vesicular structure is not visible at the surface as--when it is present--it is sealed by

Table 8. Particle size and mineral composition of the surface 18cm of a light yellowish brown soil representative of the loess soils (Typic Haplargid) from the arid region of Israel, the Negev (Barshad et al, 1956)

Particle Size					
		Clay			
Sand	Silt	<0.002mm	<0.001mm	$CaCO_3$	CEC
%					meq/100g clay
46.0	34.2	19.8	13.0	24.4	58.8

Minerals of <0.002mm Fraction (clay)				
Montmorillonite	Kaolinite	Attapulgite	Mica	Quartz
%				
55	10	35	<5	<5

a thin puddled crust of loam. Often the lower surface of the stones shows a narrow green-blue band paralleling the edges of the stones at a small distance from the surface. This band represents a micro-ecosystem (Evenari et al, 1974).

Vesicular structure is also found on soils which are shallow, especially the soil filling cracks and fissures in the igneous and metamorphic rocks of the Precambrian massif of southern Sinai. When exposing these cracks by removing the covering part of the rocks a very thin layer with vesicular structure is observed. The soil forming the vesicules is a very fine calcareous silty clay. Its origin can easily be observed when strong sudden gusts of wind in the wadis drive dust clouds up the mountain slopes and the dust then settles in all the cracks and fissures of the rocks and mixes with the local weathering detritus (Evenari et al, 1974).

A third kind of soils where vesicular structures can be found are alluvial, silty to loamy, nearly stoneless, almost level wadis, fans or depressions of flood plains, which are flooded after rainstorms and which retain the water for a short time (Evenari et al, 1974).

Vesicular structure apparently does not occur in loessial soils (Evenari et al, 1974).

Vesicular structure only takes a few to a few hundred years to form, depending on the thickness and expression (Yaalon, 1974). The major factor in sealing the surface must be considered wetting by dew, leaving a thin continuous crust after the puddled surface has dried. Though some vesicles may be formed due to air displaced by downward moving moisture or due to the release of CO_2 during drying, the major factor in the formation of the vesicles must be considered the heat expansion of trapped air below the stones or surface crust.

Outside the wadis, in southern Israel, the area is almost bare of vegetation (Sharon, 1962). Most of the soil is covered by quite closely packed angular rock fragments forming a desert pavement. This is called the Hamada. The makeup of this extensive desert pavement depends on the parent rock from which it disintegrated. Often the surface rock is flint fragments which usually do not exceed 10 cm in diameter. Limestone desert pavement has fragments of almost every size, from a few mm to >40 cm (Sharon, 1962).

In areas of moderate slope and over the accumulation area at the foot of slopes, the desert pavement is generally smooth and its components protrude only a little from the surface. On the higher, steeper parts of the slopes, the cover is coarse and mostly made up of big stones. This feature is extensively observed in the Negev and clear boundaries between the various types are mostly found on the slopes, along topographic lines (Sharon, 1962).

SOIL CLASSIFICATION

The soils described in this report have been classified according to the USDA Soil Taxonomy of the National Cooperative Soil Survey (Soil Survey Staff, 1975 and 1979). The following section describes this taxonomy system as it applies to the discussed soils.

USDA Soil Taxonomy

A category of this system is a set of classes that are defined approximately at the same level of generalization or abstraction and that include all soils. There are six categories in the system. In order of decreasing rank and increasing number of differentiae and classes, the categories are order, suborder, great group, subgroup, family, and series.

The names of orders can be recognized as such because the name of each order ends in sol with the connecting vowel o for Greek roots and i for other roots. Each name of an order contains a formative element that begins with the vowel preceding the connecting vowel and ends with the last consonant preceding the connecting vowel. In the order name Entisol, the formative element is ent. In Aridisol, it is id. These formative elements are used as endings for the names of suborders, great groups, and subgroups.

Names of suborders have exactly two syllables. The first syllable connotes something of the diagnostic properties of the soils. The second is the formative element from the name of the order.

The name of a great group consists of the name of a suborder and a prefix that consists of one or two formative elements suggesting something of the diagnostic properties. Names of great groups, therefore, have three or four syllables and end with the name of a suborder.

The name of a subgroup consists of the name of a great group modified by one or more adjectives. The adjective typic is used for the subgroup that is thought to typify the great group. Each typic subgroup has, in clearly expressed form, all the diagnostic properties of the order, suborder, and great group to which it belongs. Typic subgroups also have no additional properties indicating a transition to another great group and have no abberrant properties that require special recognition. The Torrifluvents that typify the central concept of the great group are therefore called Typic Torrifluvents. These are not necessarily the most extensive Torrifluvents. Intergrade subgroups are those that belong to one great group but that have some properties of another order, suborder, or great group. They are named by using the adjectival form of the name of the appropriate taxon as a modifier of the great group name.

Within the category of family, the intent is to group the soils within a subgroup having similar physical and chemical properties that affect their responses to management and manipulation for use. Families are defined primarily to provide groupings of soils with restricted ranges in: 1) particle size distribution in horizons of major biologic activity below plow depth, 2) mineralogy of the same horizons that are considered in naming particle size classes, 3) temperature regime, and 4) thickness of the soil penetrable by roots.

The category series is the lowest category in the system. The differentiae used for series are mostly the same as those used for classes in other categories, but the range permitted in one or more properties is less than is permitted in a family or in some other higher category.

This section on Soil Classification has been abstracted from the USDA Soil Taxonomy (Soil Survey Staff, 1975). This reference should be used for more detailed definitions of various categories.

The following are the categories of the USDA Soil Classification system used for soils of Israel, Fort Irwin, California, Yuma Proving Grounds in Arizona, Fort Huachuca in Arizona, and White Sands Missile Range in New Mexico. The categories are presented in the hierarchy equired for consideration in Soil Taxonomy (Soil Survey Staff, 1975). Each successive indentation in the text represents a lower category. The following indentation sequence is an example:

ORDER
  SUBORDER
    GREAT GROUP
      SUBGROUP

HISTOSOLS: The unique property of Histosols is a very high content of organic matter in the upper 80 cm of soil. The amount of organic matter is at least 20 to 30 percent in more than half of this thickness, or the horizon that is rich in organic matter rests on rock or rock rubble. Most Histosols are peats or mucks, which consists of more or less decomposed plant remains that accumulated in water.

SAPRISTS: The Saprists consist of almost completely decomposed plant remains. The botonic origin of the materials cannot be directly observed for the most part. The soils are black, and they tend to have bulk density >0.2 g per cubic centimeter.

VERTISOLS: These soils have marks of processes that mix the soil regularly and prevent development of diagnostic horizons that one might otherwise expect to find. Because the soil moves, the diagnostic properties have many accessory properties. Among them are high bulk density when dry, very slow hydraulic conductivity when moist, an appreciable rise and fall of the soil surface as the soil becomes moist and then dries, and rapid drying as a result of open cracks. The unique properties common to Vertisols are a high content of clay; pronounced changes in volume with changes in moisture; deep wide cracks (one cm or more wide at a depth of 50 cm) at some season; and evidences of soil movement in the form of slickensides, gilgai microrelief, and wedge-shaped structural aggregates that are tilted at an angle from the horizontal.

XERERTS: Xererts are the Vertisols, most of them in Mediterranean climates, that have cool wet winters and warm, dry summers. They have cracks that close and open regularly once each year and remain open for more than 2 of the 3 months following the summer solstice in more than 7 out of 10 years.

CHROMOXERERTS: These are Xererts that have a readily visible color in the matrix of some or all subhorizons in the upper 30 cm and present in more than half of each pedon. Commonly, the horizons that have chroma of 2 or more extend to a depth greater than 30 cm.

PELLOXERERTS: These are the Xererts that are dominantly gray to black in all subhorizons in the upper 30 cm in more than half of each pedon. Most of them are nearly level or are in depressions.

ARIDISOLS: The unique properties common to Aridisols are a combination of a lack of water available to mesophytic plants for very extended periods, one or more pedogenic horizons, a surface horizon or horizons not significantly darkened by humus, and absence of deep wide cracks. The Aridisols have no available water during most of the time that the soil is warm enough for plant growth, and they never have water continuously available for as long as 90 days when the soil temperature is above 8 C. They have an aridic or torric moisture regime.

ARGIDS: These are the Aridisols that have an illuvial horizon in which silicate clays have accumulated. In the absence of appreciable sodium on the exchange complex, finely divided carbonates must be removed before horizons of clay accumulation can form. This means, in general, that Argids that have an argillic horizon but do not have a natric horizon are formed on late-Pleistocene or older erosion surfaces or sediments. The amount of rainfall is low, leaching is very slow, and the soils that formed in Holocene sediments, except those that contain few carbonates, normally have only weak or no evidences of clay translocation. The evidences suggest that, during the glacial periods, the precipitation was more effective or greater than at present and was more effective for leaching because temperatures were somewhat lower. Because most arid regions are dusty places, a soil that lost its carbonates during the late-Pleistocene time may now be calcareous throughout its depth.

PALEARGIDS: These are the reddish Argids on stable land surfaces that either have a petrocalcic horizon below the argillic horizon or have an argillic horizon that has a clayey particle-size class and an abrupt or nearly abrupt upper boundary. Most formed in stable landscape positions from sediments rather than from residuum from parent rock. They are, for the most part, appreciably older than the latest Pleistocene. Some have been developing since mid or early Pleistocene or perhaps longer. Because of the Pleistocene pluvials, some of the petrocalcic horizons are complex and have evidences of successive periods of formation and solution. If calcareous dust has been present, some of these soils may have free carbonates in all horizons. In some, powdery lime coats peds that have noncalcareous interiors; in others a calcic horizon engulfs the lower part of an argillic horizon.

TYPIC PALEARGIDS: These are the soils which are the central concept of Paleargids.

PETROCALCIC PALEARGIDS: These are the Paleargids which have a petrocalcic horizon (hard accumulation of calcium carbonate).

HAPLARGIDS: These are the Argids that have an argillic horizon but do not have a duripan and do not have a natric or a petrocalcic horizon. Commonly, a calcic horizon lies below the argillic horizon. Generally, the soils are noncalcareous above the lower part of the argillic horizon, although some have been recharged with lime from calcareous dust or other sources. The Haplargids are mostly on late-Pleistocene erosion surfaces or sediments, and commonly they have gentle slopes. Most are in sediments that had only a little or no lime.

TYPIC HAPLARGIDS: These are the soils which are the central concept of Haplargids.

USTOLLIC HAPLARGIDS: These are the Haplargids which have properties marginal to Ustolls, that is, more moisture and more organic carbon than normal for Typic Haplargids.

XERALFIC HAPLARGIDS: These are the Haplargids which have a higher moisture content marginal to Xeralfs.

ORTHIDS: These are the Aridisols that have one or more pedogenic horizons but do not have an argillic or a natric horizon. They commonly have horizons of accumulation of soluble salts and carbonates. Some have a salic, calcic, gypsic, petrocalcic, petrogypsic, or cambic horizon or a duripan, singly or in combination. These horizons form the basis for defining the great groups. Most of the Orthids are in sediments or on erosion surfaces of late-Pleistocene age or younger. A few may be very old if a petrocalcic horizon has engulfed an argillic horizon. The Orthids are thought to be largely products of the present environment.

SALORTHIDS: These are the very salty soils of wet places in deserts where capillary rise and evaporation of water concentrate the salts into a salic horizon. Generally, the chroma is low and high-contrast mottles that are due to segregation of iron are present. These soils are mainly soils of depressions where ground water saturates the soil at some time of year in some subhorizon within 1 m of the surface. The concentration of salts is within 75 cm of the surface, and usually it is within a few centimeters of the surface or at the surface.

TYPIC SALORTHIDS: These are the soils representative of the central concept of Salorthids.

PALEORTHIDS: These are Orthids that have a petrocalcic horizon. Ordinarily, the upper boundary of the petrocalcic horizon is close to the soil surface and is thick. Some of the soils have evidence that they formerly were Argids, but the former argillic horizon has been largely engulfed and cemented by carbonates and only a few reddish, noncemented remnants of the argillic horizon persist in or below the petrocalcic horizon. Other Paleorthids formed in parent materials rich in carbonates. Generally, these soils are on gentle slopes that have been stable for long periods, at least since the last glacial period, and a number of them probably are of mid-Pleistocene age or older. The petrocalcic horizons commonly have been shattered and recemented. Laminar horizons normally are thick, at least 10 to 20 cm or more. The soils generally are calcareous throughout, and the colors range from reddish brown to nearly white.

TYPIC PALEORTHIDS: These represent the central concept of Paleorthids.

DURORTHIDS: These are the Orthids that have a duripan that has its upper boundary within 1 m of the soil surface. The common depth to the pan ranges from about 30 to 50 cm. The soils are generally gray to very pale brown, and many are calcareous throughout. They formed mostly on gentle slopes in late-Pleistocene or younger sediments that contain pyroclastics. The duripan is cemented partly with opal or chalcedony, and generally it is also partly cemented with lime.

TYPIC DURORTHIDS: These represent the central concept of Durorthids.

GYPSIORTHIDS: These are the Orthids that have a gypsic or a petrogypsic horizon whose upper boundary is within 1 m of the soil surface. Some have overlying cambic and calcic horizons. They are mostly very pale and have very little organic matter.

TYPIC GYPSIORTHIDS: These represent the central concept of Gypsiorthids.

CAMBIC GYPSIORTHIDS: These soils normally have a cambic horizon above the gypsic horizon, and the gypsic horizon has a small amount of gypsum relative to the typic subgroup.

PETROGYPSIC GYPSIORTHIDS: These soils have a petrogypsic horizon. They have had extreme development of the gypsic horizon.

CALCIORTHIDS: These are the Orthids that have had much lime in the parent materials or added in dust. The scant rainfall is unable to remove the lime completely from the surface soil to a depth of 18 cm unless the texture is sandy. The only horizons normally present are the ochric epipedon and a calcic horizon whose upper boundary generally is at a depth of less than 50 cm. A few have a cambic horizon. The soils commonly are nearly white.

TYPIC CALCIORTHIDS: These are soils representative of the central concept of Calciorthids.

AQUIC CALCIORTHIDS: These are soils which have slightly more moisture than the Typic subgroup.

LITHIC CALCIORTHIDS: These are soils which have bedrock at less than 50 cm. from the surface.

USTOLLIC CALCIORTHIDS: These are the Calciorthids which have properties marginal to Ustolls, that is, more moisture and more organic carbon than normal for Typic Calciorthids.

CAMBORTHIDS: These are Orthids that have a cambic horizon. They are brownish to reddish soils that have relatively uniform texture from the surface downward except where there is stratification in the parent material. They have a light-colored surface horizon (an ochric epipedon) over an altered (cambic) horizon that, generally, is redder or browner than the surface horizon. Either there is no pronounced horizon of carbonate accumulation (a calcic horizon) or the soil does not have free carbonates in the upper horizons to a depth of more than 18 cm.

TYPIC CAMBORTHIDS: These soils are representative of the central concept of Camborthids.

LITHIC CAMBORTHIDS: These soils have a bedrock contact within 50 cm. of the surface.

USTOLLIC CAMBORTHIDS: These soils have more moisture and more organic matter than the Typic subgroup. They are marginal to Ustolls.

MOLLISOLS: The unique properties of Mollisols are a combination of a very dark brown to black surface horizon (mollic epipedon) that makes up more than one-third of the combined thickness of the A and B horizons or that is greater than 25 cm thick and that has structure or soft consistence when dry, a dominance of calcium among the extractable cations in the A1 horizon and the B horizons, a dominance of crystalline clay minerals of moderate or high cation-exchange capacity, and less than 30 percent clay in some horizon above 50 cm if the soil has deep wide cracks (1 or more cm wide) above this depth at some season.

XEROLLS: These soils are Mollisols of regions that have Mediterranean climates. They have, as their name implies, mostly a xeric moisture regime but a few that are marginal to Aridisols have an aridic regime. They are dry for extended periods in summer, but in most of them moisture moves through the soil in winter and is stored throughout the soil above the deep layers or above bedrock in most years.

ARGIXEROLLS: These are the Xerolls that have a relatively thin argillic horizon or one in which the percentage of clay decreases rapidly with depth. Mostly the epipedon is very dark brown and the argillic horizon is dark brown. Most of these soils have a ca horizon or a calcic horizon below or in the lower part of the argillic horizon.

HAPLOXEROLLS: These are the Xerolls that have a cambic horizon or a layer of only slightly altered parent materials below the mollic epipedon. Most of these soils have horizons in which carbonates have accumulated. Many have a calcic horizon, but in them at least parts of the surface horizons are free of carbonates.

ARIDIC LITHIC HAPLOXEROLLS: These soils have a contact with bedrock within 50 cm and they are marginal to Aridisols.

ENTIC HAPLOXEROLLS: These soils do not have a cambic horizon, and their base saturation is 75 percent or less in some part of the upper soil to a depth of 75 cm.

LITHIC HAPLOXEROLLS: These soils have a contact with bedrock within 50 cm.

VERTIC HAPLOXEROLLS: These soils have clayey texture, deep wide cracks, and marked shrink-swell characteristics. They are marginal to Vertisols.

USTOLLS: The Ustolls are the more or less freely drained Mollisols of middle to low latitudes and subhumid to semiarid climates. Rainfall comes mainly during a growing season, often in heavy showers, but is erratic. Drought is frequent and may be severe. They have an ustic moisture regime.

CALCIUSTOLLS: These are mostly Ustolls that have a calcic or petrocalcic horizon and that are calcareous in all overlying horizon. Either the parent materials had more carbonates than the limited rainfall could remove from the upper horizons or there is a continuing external source of carbonates in dust or water.

ARIDIC CALCIUSTOLLS: These soils are marginal to Aridisols.

PETROCALCIC CALCIUSTOLLS: These are the Calciustolls which have petrocalcic horizons.

HAPLUSTOLLS: These are the Ustolls that have a cambic horizon or that consist of only slightly altered parent materials below the mollic epipedon. Most of them have a horizon in which carbonates or soluble salts have accumulated. A few have a calcic horizon if their parent materials had a moderate amount of lime, but in these an appreciable part of the epipedon has lost its carbonates.

LITHIC HAPLUSTOLLS: These soils have a bedrock contact within 50 cm of the surface.

TORRIORTHENTIC HAPLUSTOLLS: These soils are dry and marginal to Torriorthents.

UDORTHENTIC HAPLUSTOLLS: These soils are moist and marginal to Udorthents.

ARGIUSTOLLS: These are the Ustolls that have an argillic horizon (silicate clay accumulation) in or below the mollic epipedon. Most of them have a ca horizon or a calcic horizon below the argillic horizon, and some have an sa or cs horizon below the ca horizon. They are mostly in late-Pleistocene deposits or on surfaces of comparable age in relatively stable positions. Their slopes are mostly moderate or nearly level.

LITHIC ARGIUSTOLLS: These soils have a bedrock contact within 50 cm of the surface.

UDIC ARGIUSTOLLS: These soils receive more precipitation than typical Argiustolls or they receive runoff from other soils. The ca horizon or the calcic horizon is deeper than in typical Argiustolls.

ALFISOLS: Soils in the order of Alfisols have marks of processes that translocate silicate clays without excessive depletion of bases and without dominance of the processes that lead to formation of a mollic epipedon. The unique properties of Alfisols are a combination of an ochric or an umbric epipedon, an argillic horizon, a medium to high supply of bases in the soil, and water available to mesophytic plants more than half the year or more than 3 consecutive months during a warm season.

AQUALFS: Aqualfs are the gray and mottled Alfisols that have an aquic moisture regime or are artificially drained. In some, ground water is near the surface during a considerable part of the year but drops to depths below the argillic horizon in another part of the year. In others, the ground water may be deep most of the year but horizons that have low hydraulic conductivity restrict the downward movement of water and extend the period of saturation.

ALBAQUALFS: Albaqualfs are the Aqualfs that, seasonally, have ground water perched above a slowly permeable argillic horizon. An albic horizon rests abruptly on the argillic horizon, commonly with virtually no transitional horizon between the two.

TYPIC ALBAQUALFS: These soils represent the central concept of Albaqualfs.

AERIC ALBAQUALFS: These soils are drier than the Typic subgroup.

USTALFS: Ustalfs are the mostly reddish Alfisols of warm subhumid to semiarid regions. They usually have, as their name implies, an ustic moisture regime, that is, they have a warm rainy season and in most of them moisture moves through the soil to deeper layers only in occasional years. If there are carbonates in the parent materials or in the dust that settles on the surface, they tend to have a ca or a calcic horizon below or in the argillic horizon. The dry season or seasons are pronounced enough that trees are either deciduous or xerophytic.

HAPLUSTALFS: Haplustalfs are the relatively thin, reddish to brownish but not dark red or dusky red. Ustalfs that do not have a petrocalcic horizon within 1.5 m and that have a gradual or clear but not abrupt upper boundary of the argillic horizon, do not have a natric horizon, do not have a duripan that has its upper boundary within 1 m of the surface, and do not have much plinthite. These are the Ustalfs on relatively recent erosion surfaces or deposits, most of them late Pleistocene in age.

UDIC HAPLUSTALFS: These soils are moist and marginal to an udic moisture regime.

XERALFS: Xeralfs are mostly reddish Alfisols of regions that have a Mediterranean climate. Most have, as their name implies, a xeric moisture regime. They are dry for extended periods in summer, but in many of them moisture moves in winter through the soil to deeper layers in at least occasional years if not in most years.

RHODOXERALFS: Rhodoxeralfs are the more or less dark red Xeralfs that form in limestone, basalt, and other highly basic parent materials. As a group, these soils are remarkably uniform in virtually all properties except depth to rock. A few that are receiving carbonates may have a calcic or a petrocalcic horizon below the argillic horizon.

TYPIC RHODOXERALFS: These soils represent the central concept of Rhodoxeralfs.

CALCIC RHODOXERALFS: These soils have a calcic horizon whose upper boundary is within 1.5 m of the soil surface.

PALEXERALFS: Palexeralfs are the reddish, but not dark red or dusky red, Xeralfs that have a thick argillic horizon. Many of them have some plinthite in their lower horizons, but this is rare in the United States. These soils are in relatively stable landscape positions on gentle slopes, and their genesis began before the late Pleistocene. During the Pleistocene pluvial periods, carbonates appear to have been almost completely removed from the argillic horizon of these soils, but some of the soils appear to have been recalcified later.

PETROCALCIC PALEXERALFS: These soils have a petrocalcic horizon whose upper boundary is within 1.5 m of the surface.

HAPLOXERALFS: These are the relatively thin, reddish to brownish but not dark red or dusky red Xeralfs that have a clear or gradual upper boundary to an argillic horizon or have a loamy particle-size class throughout the argillic horizon.

CALCIC HAPLOXERALFS: These soils have a calcic horizon within 1 m of the soil surface.

MOLLIC HAPLOXERALFS: These soils have an epipedon which meets all the requirements of a mollic epipedon except it is both massive and hard when dry. The organic matter content of the surface is higher then the Typic subgroup.

VERTIC HAPLOXERALFS: These soils have deep wide cracks in most years.

INCEPTISOLS: The unique properties of Inceptisols are a combination of water available to plants during more than half the year or more than 3 consecutive months during a warm season; one or more pedogenic horizons of alteration or concentration with little accumulation of translocated materials other than carbonates or amorphous silica; texture finer than loamy sand; some weatherable minerals; and moderate to high capacity of the clay fraction to retain cations. In addition, Inceptisols do not have one or more of the unique properties of the order of Mollisols, which are the thick, dark surface horizon, the high calcium supply, and the crystalline clays.

AQUEPTS: These are the wet Inceptisols. Their natural drainage is poor or very poor and, if they have not been artificially drained, ground water stands close to the surface at some time during each year but not at all seasons. They mostly have a gray to black surface horizon and a mottled gray subsurface horizon that begins at a depth of less than 50 cm. A few have a brownish surface horizon that is less than 50 cm thick.

HAPLAQUEPTS: These are the light colored, gray Aquepts that are mostly in humid climates in midlatitudes. They do not have a fragipan or duripan, but either they have ground water that stands at or near the surface for long periods but not throughout the year or they have been drained.

TYPIC HAPLAQUEPTS: These soils represent the central concept of Haplaquepts.

AERIC HAPLAQUEPTS: These soils are drier than the Typic subgroup.

OCHREPTS: Ochrepts are mainly the light colored, brownish, more or less freely drained Inceptisols of mid to high latitudes. They have formed on nearly level to steep surfaces of late-Pleistocene or Holocene age.

XEROCHREPTS: These are the reddish or brownish Ochrepts of Mediterranean climates. They are moist in winter or spring but are thoroughly dry in summer. Many of them have steep slopes and are shallow over rock, but others developed in Holocene sediments.

CALCIXEROLLIC XEROCHREPTS: These soils have a calcic horizon or a ca horizon that contains soft powdery lime.

LITHIC XEROCHREPTS: These soils have a contact with bedrock within 50 cm of the surface.

LITHIC VERTIC XEROCHREPTS: These soils have a contact with bedrock within 50 cm of the surface and the soils have clayey texture and have deep wide cracks in summer.

VERTIC XEROCHREPTS: These soils have clayey textures and have deep wide cracks in summer.

ENTISOLS: The absence of marks in the soil of any major set of soil forming processes is itself an important distinction. There can be no accessory characteristics. The unique properties common to Entisols are dominace of mineral soil materials and absence of distinct pedogenic horizons. Entisols are soils in the sense that they support plants, but they may be in any climate and under any vegetation. The absence of pedogenic horizons may be the result of an inert parent material such as quartz sand, in which horizons do not readily form; of formation from a hard, slowly soluble rock such as limestone, which leaves little residue; of the lack of time for horizons to form, as in recent deposits of ash or alluvium; of occurrence on slopes where the rate of erosion exceeds the rate of formation of pedogenic horizons; or of recent mixing of horizons by animals or by plowing to a depth of 1 or 2 m.

AQUENTS: These are the wet Entisols.

HAPLAQUENTS: These soils are wet Aquents, mostly in upland depressions where fresh sediments do not accumulate significantly.

PSAMMENTS: These are mainly Entisols in poorly graded (well sorted) sands of shifting or stabilized sand dunes, in cover sands, or in sandy parent materials that were sorted in an earlier geologic cycle. A few are in sands that were sorted by water and are on sandy natural levees or beaches.

TORRIPSAMMENTS: These are the sands of arid climates. Many are in dunes, some are stabilized, and some are moving. They may have any mineralogy, may consist of quartz, mixed sands, or even gypsum, and may have any color.

TYPIC TORRIPSAMMENTS: These soils represent the central concept of Torripsamments.

XERIC TORRIPSAMMENTS: These soils have a moisture that borders on xeric.

QUARTZIPSAMMENTS: These are the freely drained quartz sands of humid to semiarid regions in mid or low latitudes. They may be white or stained with shades of brown, yellow, or red. Because they have virtually no minerals that can weather, they occur on some extremely old land surfaces. They also occur on late-Pleistocene and younger surfaces.

XEROPSAMMENTS: These are the Psamments of Mediterranean climates that have weatherable minerals, commonly feldspars, in the sand fraction.

LITHIC XEROPSAMMENTS: These soils have a bedrock contact within 50 cm of the soil surface.

FLUVENTS: These are mostly brownish to reddish soils that formed in recent water-deposited sediments, mainly on flood plains, fans, and deltas of rivers and small streams but not in back swamps where drainage is poor.

XEROFLUVENTS: These are the Fluvents that have a xeric moisture regime.

TYPIC XEROFLUVENTS: These soils represent the central concept of Xerofluvents.

TORRIFLUVENTS: These are the Fluvents of arid climates that are not flooded frequently or for long periods. They have a torric moisture regime and most of them are alkaline or calcareous and are somewhat salty in some places.

TYPIC TORRIFLUVENTS: These soils represent the central concept of Torrifluvents.

ANTHROPIC TORRIFLUVENTS: These soils have an anthropic epipedon, that is, a man induced, organic carbon rich surface layer.

USTIC TORRIFLUVENTS: These soils receive more moisture, either from rain or run on, than typical Torrifluvents.

ORTHENTS: These are primarily Entisols on recent erosional surfaces. The erosion may be geologic or may have been induced by cultivation or other factors, but any former soil that existed has been completely removed or so truncated that the diagnostic horizons for all other orders are absent.

TORRIORTHENTS: These are the dry or salty Orthents of cool to hot arid regions. They have a torric moisture regime or are salty or both. Mostly, they are neutral or calcareous and are on moderate to strong slopes. A few have gentle slopes. Many of the gently sloping soils are on rock pediments, have a sandy-skeletal particle-size class, or are salty. Others are on fans where sediments are recent but had little organic carbon.

TYPIC TORRIORTHENTS: These soils represent the central concept of Torriorthents.

LITHIC TORRIORTHENTS: These soils have a bedrock contact within 50 cm of the surface.

XERORTHENTS: These are the Orthents of Mediterranean climates that have a xeric moisture regime. Most Orthents are strongly sloping and lose water by runoff, so that not all Orthents in Mediterranean climate have a xeric moisture regime, particularly if the regolith is thick. But the winter rains usually are gentle, summer drought is certain, and most of the Orthents in a Mediterranean climate are Xerorthents.

TYPIC XERORTHENTS: These soils represent the central concept of the Xerorthents.

LITHIC XERORTHENTS: These soils have a bedrock contact within 50 cm of the soil surface.

USTORTHENT: These are the Orthents of mid or low latitudes that have an ustic soil moisture regime.

TYPIC USTORTHENT: These soils represent the central concept of the Ustorthents.

LITHIC USTORTHENT: These soils have a bedrock contact within 50 cm of the soil surface.

The soils are classified at the family level according to particle-size classes, among other factors. The particle-size classes are shown in Figure 4. Particle size at the family level refers to grain-size distribution of the whole soil and is not the same as texture, which refers to the fine-earth fraction. Tables 9 and 10 shows fine-earth texture classification used in general soil descriptions. The fine-earth fraction consists of the particles that have a diameter <2 mm. The family particle size classes used in this report are as follows:

SANDY-SKELETAL: Rock fragments 2 mm in diameter or larger make up 35% or more by volume; enough fine earth to fill interstices larger than 1 mm; the fraction finer than 2 mm is sandy as defined for the sandy particle-size class.

LOAMY-SKELETAL: Rock fragments make up 35 percent or more by volume; enough fine earth to fill interstices larger than 1 mm; the fraction finer than 2 mm is loamy as defined for the loamy particle-size class.

CLAYEY-SKELETAL: Rock fragments make up 35 percent or more by volume; enough fine earth to fill interstices larger than 1 mm; the fraction finer than 2 mm is clayey as defined for the clayey particle-size class.

SANDY: The texture of the fine earth is sand or loamy sand but not loamy very fine sand or very fine sand; rock fragments make up <35% by volume.

LOAMY: The texture of the fine earth is loamy very fine sand, very fine sand, or finer, but the amount of clay is <35%; rock fragments make up <35 percent by volume.

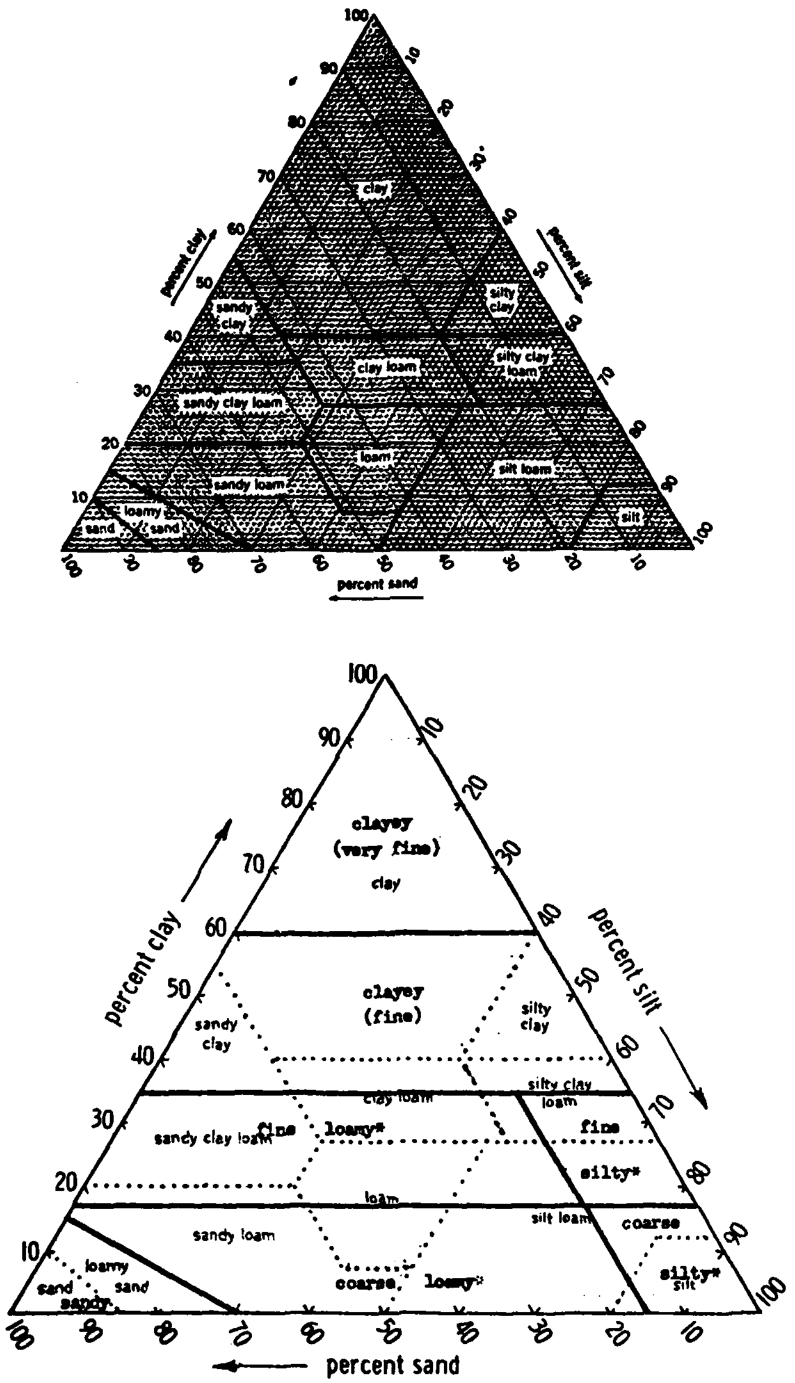

Figure 4. Texture triangles--the lower diagram shows the family texture classes superimposed on the USDA Particle Size Classes.

Table 9. Particle size distribution in the USDA Soil Texture Classes (Soil Survey Staff, 1951)

Particle Names	Diameter
	----mm----
Very coarse Sand	2-1
Coarse sand	1-0.5
Medium sand	0.5-0.25
Fine sand	0.25-0.1
Very fine sand	0.1-0.05
Silt	0.05-0.002
Clay	<0.002

Table 10. General grouping of soil textural class names used in soil classification (Soil Survey Staff, 1951)

General Texture Terms		Basic Soil Textural Class Names
Sandy soils	Coarse-textured soils	Sands Loamy sands
Loamy soils	Moderately coarse-textured soils	Sandy loam Fine sandy loam
	Medium textured soils	Very fine sandy loam Loam Silt
	Moderately fine-textured soils	Clay loam Sandy clay loam Silty clay loam
Clayey soils	Fine-textured soils	Sandy clay Silty clay Clay

COARSE-LOAMY: By weight, 15% or more of the particles are fine sand or coarser, including fragments up to 7.5 cm in diameter; <18% clay in the fine-earth fraction.

FINE-LOAMY: By weight, 15% or more of the particles are fine sand or coarser, including fragments up to 7.5 cm in diameter; 18 through 34 percent clay in the fine-earth fraction.

COARSE-SILTY: By weight, <15 percent of the particles are fine sand or coarser, including fragments up to 7.5 cm in diameter; <18% clay in the fine-earth fraction.

FINE-SILTY: By weight, <15% of the particles are fine sand or coarser, including fragments up to 7.5 cm in diameter; 18 through 34 percent clay in the fine-earth fraction.

CLAYEY: The fine earth contains 35 percent or more clay by weight, and rock fragments are <35% by volume.

FINE: A clayey particle size class that has 35 through 59% clay in the fine-earth fraction.

The mineralogy classes used in this report are self descriptive. The name is descriptive and that mineral dominates the soil.

The temperature classes are as follows:

MESIC: 8 to 15C mean annual soil temperature. THERMIC: 15 to 22C mean annual soil temperature. HYPERTHERMIC: >22C mean annual soil temperature.

The only depth class used is shallow. This indicates that the soil is less than 50 cm to a restricting zone for roots.

SOIL MAP UNITS

Soil maps of Israel, Yuma Proving Grounds, Arizona, Fort Irwin, California, Fort Huachuca, Arizona, and the White Sands Missile Range, New Mexico, are included in this section along with their map unit descriptions. These soil maps are of a general scale and should be used only to obtain a broad picture of the soils of the area.

A soil map of Israel is shown in Figure 5. A list of the soils of Israel converted to the USDA soil taxonomy is in Table 11.

A soil map of the Yuma Proving Grounds, Arizona, is shown in Figure 6. A list of the soils of the area is in Table 12.

A soil map of the area which includes Fort Irwin, California, is shown in Figure 7. A list of the soils used in the description of the area is in Table 13.

A soil map of Fort Huachuca, Arizona, is shown in Figure 8. A list of the soils used to describe the soils is in Table 14. A list of the series which surround the Fort included in a recent soil survey are also included in Table 14 (Richardson et al, 1979).

A soil map of the White Sands Missile Range is shown in Figure 9. A list of the soil series used to describe the soils is in Table 15. The map unit description were abstracted from Maker et al (1978). The list of series in Table 15 is from a more detailed soil survey of White Sands by Neher and Bailey (1976).

Table 16 compares the soils of all five areas according to USDA Soil Taxonomy terminology. All of the soils of Israel are shown in this table. Areas can be compared by first determining the classification of the component soils in the map units.

Map Unit Descriptions of the Soils of Israel

A. Xerochrept, Haploxerolls, Argixerolls, Rhodoxeralfs and Haploxerolls (Terra Rossas, Brown Rendzinas and Pale Rendzinas).

This map unit is composed mainly of Xerochrepts, Haploxerolls and some Argixerolls and Rhodoxeralfs with inclusions of Lithic Haploxerolls and Lithic and Typic Xerorthents and Entic and Lithic Haploxerolls in addition to numerous outcrops of limestone. The soil depth differs greatly within short distances, so that deep soils occurring in solution pockets or in hollows alternate abruptly with rock outcrops. Xererts form inclusions on bottomland. Torrifluvents and Xerofluvents occur in narrow valleys.

The Xerochrepts, Haploxerolls, Argixerolls and Rhodoxeralfs are reddish-brown to red, fine-textured, mostly noncalcareous ABR or AR soils on hard limestone, dolomite or sometimes Nari lime crust. The upper horizon is granular to subangular blocky and usually somewhat darker colored than the underlying layer. The deeper horizon is subangular blocky, blocky or prismatic. The transition to the underlying rock is abrupt. Most of these soils are quite shallow and many rock outcrops appear in their area of distribution. However, the soil in the pockets and cracks may be deep.

The Lithic Haploxerolls are dark to very dark brown, fine textured, noncalcareous to calcareous soils with an ABR or AR horizon sequence on Nari lime crust, hard chalk and occasionally hard limestone. The upper horizon is relatively rich in organic matter and darker colored than the underlying layer. The structure of the A horizon is granular, while in the deeper layer it becomes subangular blocky. Most of these soils are quite shallow and many rock outcrops appear in their area of distribution. The transition to the underlying rock is mostly rather sharp.

The Lithic and Typic Xerorthents and the Entic and Lithic Haploxerolls are brown to light gray, loamy, clay-loamy or sometimes clayey, highly calcareous soils with an AC horizon sequence on soft calcareous sediments. The A horizon is crumbly; the transition to the soft rock is gradual.

The dominant family for the soils in this map unit is fine, mixed, thermic.

These soils form mainly from hard limestone and dolomite with inclusions of chalk, marl and calcareous shale. This association occurs in the mountainous and hilly regions. Steep slopes comprise most of the area, but moderate slopes and small plateaus occur occasionally near summits and water-divides. Karstic features characterize most of these areas. Surface water runoff is less than 10% of total rainfall.

This association is typical for most of the hilly area of northern and central Israel.

B. Lithic Haploxerolls and Lithic and Typic Xerorthents (Brown Rendzinas and Pale Rendzinas).

This map unit is mainly shallow Lithic Haploxerolls with numerous out-

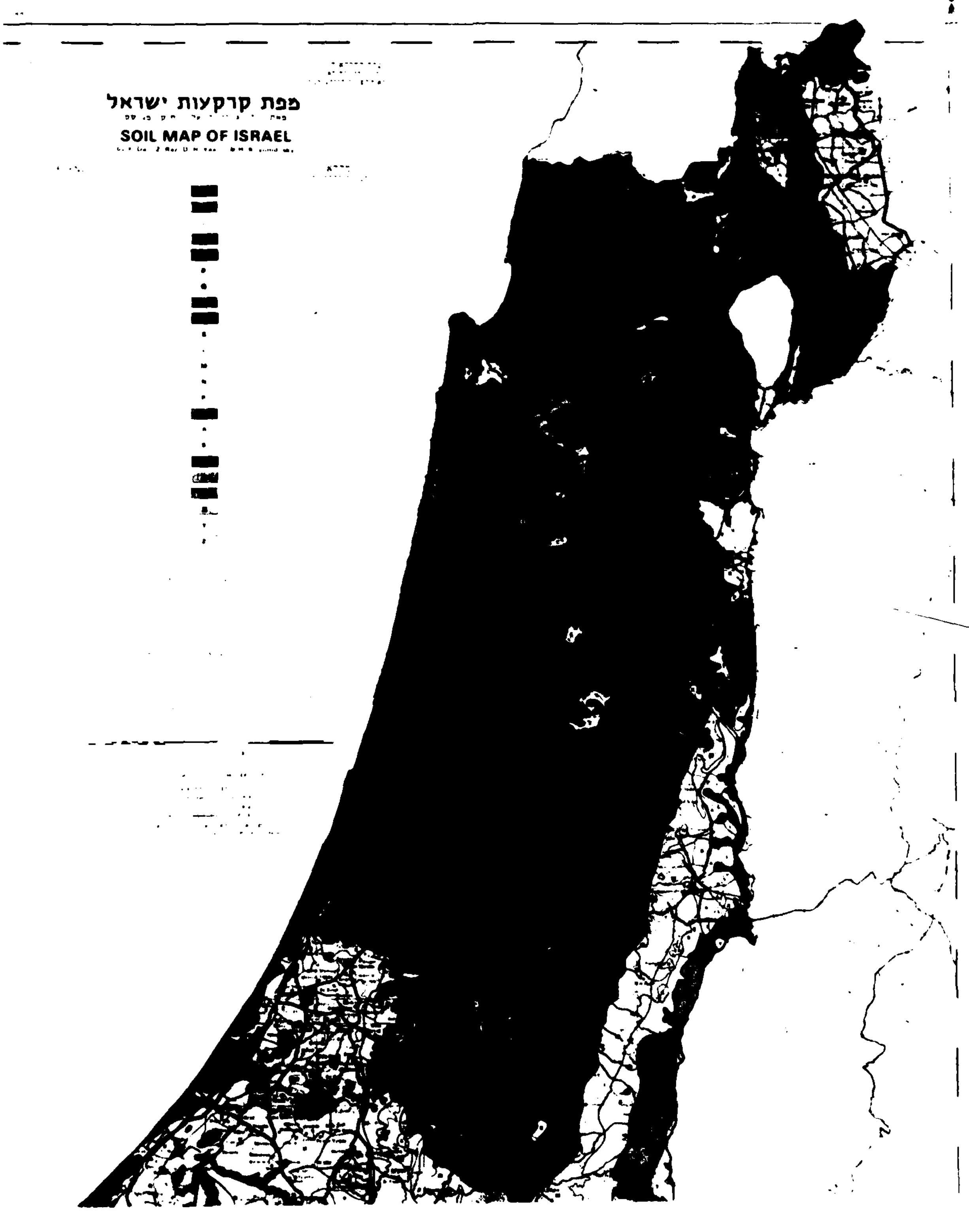

FIGURE 5. SOIL MAP OF ISRAEL (DAN ET AL, 1976).
NOTE: REPRODUCTION FROM ORIGINAL COLOR PRINT CAUSES LOSS OF DETAIL.

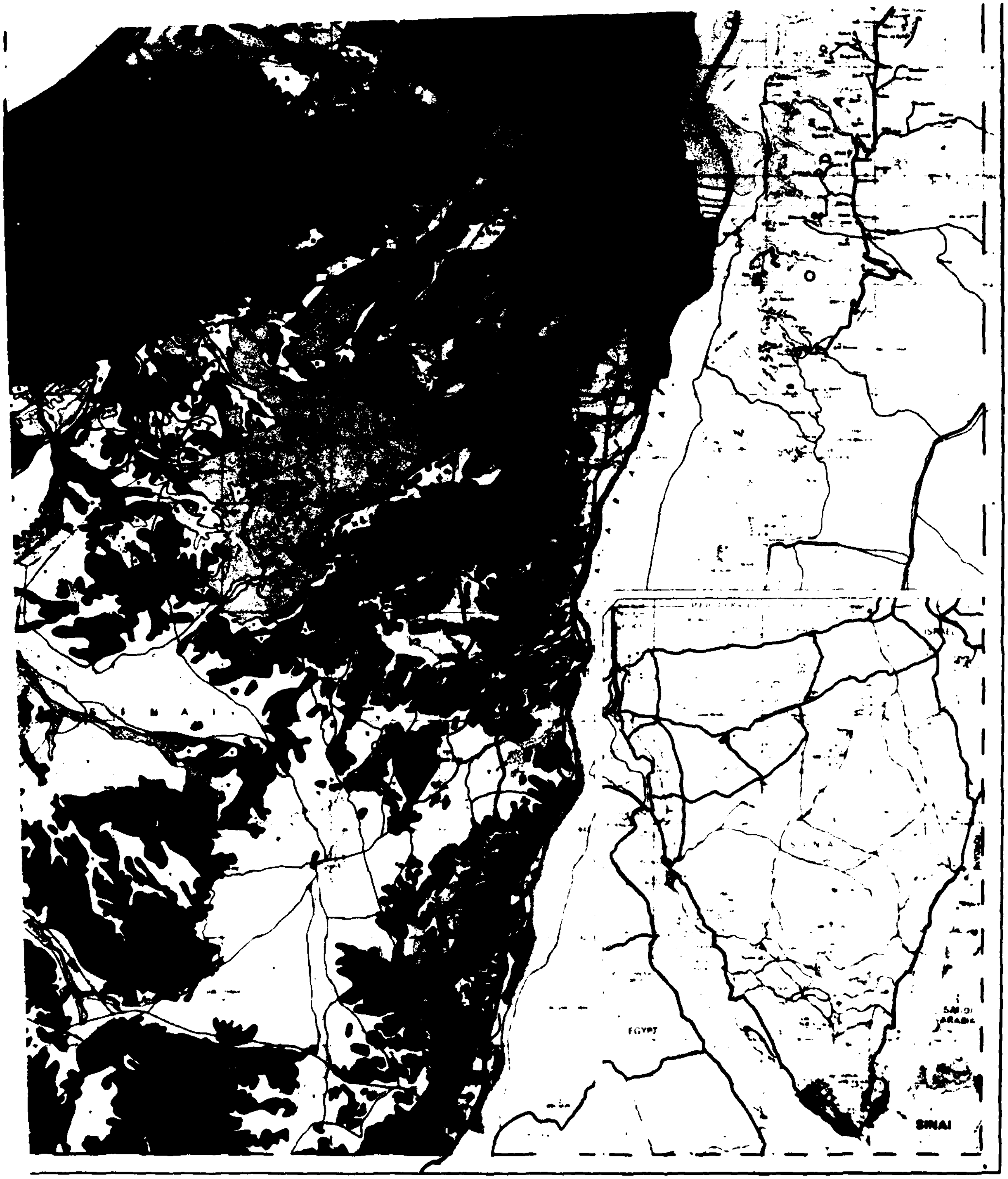

FIGURE 5 (CONT)

Table 11. Classification of the soils of Israel (Dan et al, 1976)

Israel Soil Classification	USDA Soil Classification Equivalent
Alluvial	Xerofluvents Haploxerolls Xerochrepts
Alluvial Brown	Typic Haplargids Typic Camborthids
Basaltic and Tuffic Red Mediterranean	Typic Rhodoxeralfs
Basaltic Brown Mediterranean	Mollic Haploxeralfs Haploxerolls
Basaltic Lithosols	Lithic Xerorthents
Brown Hamra	Mollic Haploxeralfs
Brown Lithosols	Lithic Torriorthents Aridic Lithic Haploxerolls
Brown Rendzinas	Lithic Haploxerolls
Calcareous Desert Lithosols	Lithic Torriorthents
Calcareous Serozems	Calcixerollic Xerochrepts Typic Calciorthids Cambic Gypsiorthids
Coarse Desert Alluvium	Typic Torrifluvents Typic Torripsamments
Colluvial-Alluvial	Xerofluvents Haploxerolls Xerochrepts
Colluvial-Alluvial Loess	Typic Torrifluvents Typic Xerofluvents
Gley and Hydromorphic	Haplaquents Haplaquepts
Grumusols	Xererts
Grumusolic Dark Brown	Vertic Haploxeralfs Vertic Xerochrepts Chromoxererts

Table 11. (Cont.) Classification of the soils of Israel

Israel Soil Classification	USDA Soil Classification Equivalent
Hamra	Typic Rhodoxeralfs
Highly Calcareous Loamy Alluvial	Typic Torrifluvents
Husmas	Calcic Rhodoxeralfs
Hydromorphic Grey Calcareous	Aquic Calciorthids Typic Haplaquepts Aeric Haplaquepts
Loess and Desert Alluvial	Typic Torrifluvents Typic Xerofluvents
Loessial Arid Brown	Calcic Haploxeralfs Calcixerollic Xerochrepts
Loessial Serozems	Typic Haplargids
Nazaz (Pseudogley)	Typic Albaqualfs Aeric Albaqualfs
Pale Rendzinas	Lithic Xerorthents Typic Xerorthents Entic Haploxerolls Lithic Haploxerolls
Pararendzinas	Lithic Haploxerolls Lithic Xerochrepts Lithic Xerorthents Lithic Xeropsamments
Peat and Organo-Mineral	Saprists
Reg	Cambic Gypsiorthids Petrogypsic Gypsiorthids Camborthids
Regosols	Typic Xerorthents Typic Torriorthents
Rendzinic Desert Lithosols	Lithic Torriorthents Aridic Lithic Haploxerolls
Residual and Cummulic Dark Brown	Calcic Haploxeralfs Calcixerollic Xerochrepts
Residual Quartzic-Psammic Arid Brown	Calcic Haploxeralfs

Table 11. (Cont.) Classification of the soils of Israel

Israel Soil Classification	USDA Soil Classification Equivalent
Residual Quartsic-Psammic Serozems	Typic Haplargids Typic Calciorthids
Sandy	Quartzipsamments Typic Torripsamments Xeric Torripsamments
Solonchaks	Salorthids
Stony Arid Brown	Petrocalcic Palexeralfs Calcic Haploxeralfs Calcixerollic Xerochrepts
Stony Serozems	Typic Paleorthids Typic Calciorthids Typic Haplargids Petrocalcic Paleargids
Terra Rossas	Xerochrepts Haploxerolls Argixerolls Rhodoxeralfs

crops of limestone or calcareous crust (Nari, calcrete). The shallow to moderately deep Lithic and Typic Xerorthents are typical of slopes where the calcareous crust has been eroded. Xererts and Vertic Haploxeralfs, Vertic Xerochrepts and Chromoxererts form inclusions in bottomland and on small plateaus, while Xerofluvents with some Haploxerolls and Xerochrepts occur in narrow valleys.

The Lithic Haploxerolls are dark to very dark brown, fine-textured, noncalcareous to calcareous soils with an ABR or AR horizon sequence on Nari lime crust, hard chalk and occasionally hard limestone. The upper horizon is relatively rich in organic matter and darker colored than the underlying layer. The structure of the A horizon is granular, while in the deeper layer it becomes subangular blocky. Most of these soils are quite shallow and many rock outcrops appear in their area of distribution. The transition to the underlying rock is mostly rather sharp.

The Lithic and Typic Xerorthents and the Entic and Lithic Haploxerolls are brown to light gray, loamy, clay-loamy or sometimes clayey, highly calcalcareous soils with an AC horizon sequence on soft calcareous sediments. The A horizon is crumbly; the transition to the soft rock is gradual.

The dominant families of the soils of this map unit are fine and fine-loamy, mixed, thermic.

These soils form mainly from soft chalk and marl covered partly by Nari lime crust (calcrete, petrocalcic) and hard chalk. The topographic pattern is characterized by steep slopes. Moderate slopes and plateaus are widespread on or near mountain summits. The hills are dissected by many valleys, some of them quite large.

This association covers parts of the hilly country in northern and central Israel.

C. Lithic and Typic Xerorthents (Pale Rendzinas).

This map unit is composed mainly of Lithic and Typic Xerorthents which cover most of the hilly slopes. These soils are shallow on steep slopes, but become gradually deeper on the hill crests and moderate slopes. Highly calcareous gray and grayish-brown Xerofluvents with some Haploxerolls and Xerochrepts characterize the narrow valleys and footslopes. Brown soils may be found in the broader valleys.

The Lithic and Typic Xerorthents and the Entic and Lithic Haploxerolls are brown to light gray, loamy, clay-loamy or sometimes clayey, highly calcalcareous soils with an AC horizon sequence on soft calcareous sediments. The A horizon is crumbly; the transition to the soft rock is gradual.

The dominant families of the soils in this map unit are fine-loamy and fine, mixed, thermic.

These soils formed mainly from soft chalk and marl. They occur on moderate to steep hills with broad valleys between them.

This association is restricted to small areas in the hilly and mountainous areas of northern and central Israel.

D. Vertic Lithic Xerochrepts, Vertic and Lithic Haploxerolls, Chromoxererts and Lithic and Typic Xerorthents (Basaltic Protogrumusols, Basaltic Brown Grumusols and Pale Rendzinas).

This association is dominated by Lithic and Typic Xerorthents and by Vertic Lithic Xerorhrepts and, Vertic and Lithic Haploxerolls. Sometimes. Lithic Haploxerolls occur. The Vertic Lithic Xerochrepts and Vertic and Lithic Haploxerolls also cover eroded plateaus. The more gentle slopes and noneroded plateaus are occupied by brown Xererts.

The Vertic Lithic Xerochrepts and Vertic and Lithic Haploxerolls are shallow, fine-textured soils with an AC or ACR horizon sequence on basaltic rocks. These soils are usually noncalcareous, stony and with many outcropping rocks.

The Xererts have an AC horizon sequence with heavy texture. The clay fraction consists of expanding clay minerals which cause the soil to crack badly during the alternating wet and dry seasons, and the soils show evidence of considerable churning action. The soils may contain calcium carbonate. Three structural horizons may be observed: an upper granular horizon, a columnar horizon, and a deeper bicuneate (polyhedric) horizon. The wedge-like faces are mostly at an angle of about 45 degrees to the horizon; slickensides are seen on these faces. Brown (Chromoxererts), and gray (Pelloxererts) types are distinguished. The Chromoxererts are found on better drained areas, while the Pelloxererts characterize undrained depressions. These soils formed either from fine-textured alluvial or eolian material or from basalt.

The Lithic and Typic Xerorthents and the Entic and Lithic Haploxerolls are brown to light gray, loamy, clay-loamy or sometimes clayey, highly cal-calcareous soils with an AC horizon sequence on soft calcareous sediments. The A horizon is crumbly; the transition to the soft rock is gradual.

The dominant families for the soils of this map unit are fine, mixed, thermic and hyperthermic.

These soils mainly formed from basalts, chalk and shales. They are on basaltic plateaus. Many of the steep slopes owe their origin to faulting.

This association is found on the slopes of the dissected basaltic plateaus of eastern Lower Galil and Lower Golan, as well as on eroded parts of the basaltic plateaus in these regions.

E. Typic Rhodoxeralfs (Hamra).

The undulating to sloping hills are covered by red Typic Rhodoxeralfs, while on the lower slopes, and sometimes also on small plateaus, or in depressions, Typic and Aeric Albaqualfs are found. The broader valleys are occupied by brown Typic Rhodoxeralfs, various Xerofluvents, Haploxerolls and Xerochrepts, and Xererts. Lithic and Typic Xerorthents cover the steep slopes of the Kurkar (eolianite) hills.

The Typic Rhodoxeralfs have an ABC horizon sequence. The A horizon is brown, sandy, and massive to loose. Red textural B horizon characterizes this soil. There are continuous clay coatings on ped surfaces in the B horizon, which has a strong blocky or prismatic structure. In sandy soils this horizon is single-grained to massive. Organic matter is low. The soils are formed on sandy parent material. They are slightly acid to neutral and noncalcareous.

The dominant families for the soils in this map unit are coarse-loamy and fine-loamy, mixed, thermic.

These soils formed mainly from coastal sand and calcareous sandstone (eolianite). Coarse, medium and fine-textured alluvial sediments are in the valleys. This association occupies an undulating to rolling topography, alternating with broad valleys. Typically the topographic pattern consists of calcareous sandstone and ancient sand ridges enclosing sandy plains or even peaty swamps.

This association is typical for the central coastal plain of Israel.

F. Mollic Haploxeralfs, Haploxerolls and Lithic Xerorthents (Basaltic Brown Mediterranean and Basaltic Lithosols).

Mollic Haploxeralfs with some Haploxerolls cover most of the older lava flows and the flat areas in this association. Lithic Xerorthents characterize the youngest lava flows, dikes, and sloping eroded areas. Pelloxererts can be found along undrained depressions. Volcanic cones are covered by deep, tuffic, red Haploxeralfs and Haploxerolls or by tuffic Typic Xerorthents.

The Mollic Haploxeralfs and Haploxerolls have an ABR or ABCR horizon sequence. The A horizon is yellowish-brown and silty. The textural B consists of brown clay or clay loam which has a prismatic or a blocky structure; continuous clay coatings cover the aggregate surfaces. The soils are usually slightly acid. They were formed from Pleistocene basalt.

The Lithic Xerortents are shallow soils with an AR horizon sequence that cover basalt rocks. The soils are yellowish-brown, loamy and noncalcareous. The transition to the underlying rock is usually sharp.

The dominant family for the soils of this map unit is fine-loamy, mixed, thermic.

These soils are formed mainly in Pleistocene basalt. Scoria, tuff and volcanic ash are also parent materials near the volcanic cones. This association is characterized by Pleistocene basaltic flows, some extrusive dikes and volcanic cones. The topography is somewhat undulating; steep slopes are restricted to the volcanic cones.

This association is found in the higher parts of the Golan plateau.

G. Haplaquents and Haplaquepts (Gley and Hydromorphic).

This association includes mainly Haplaquents, Haplaquepts, Pelloxererts, and Saprists. Locally, on river levees, even medium- to fine-textured Xerofluvents belong in the map unit.

The Haplaquents and Haplaquepts are generally fine-textured, calcareous soils with a prominent gley layer in the profile. They are formed from fine alluvial material of sites where nonsaline groundwater seasonally comes close to the surface.

The dominant family of the soils of this map unit is fine, mixed, thermic.

These soils are derived from fine-textured alluvial sediments. The peat was formed from decaying swamp vegetation. These soils are on flat level land. The water table often reaches the surface during the winter rains, and flooding may last several weeks or months.

This association is restricted mainly to the lower lying undrained parts of the large valleys in the north of Israel. Small areas also occur in the northern and central parts of the coastal plain.

H. Chromoxererts and Pelloxererts (Grumusols).

In this map unit, the smooth to gently sloping topography is almost completely occupied by Chromoxererts and Pelloxererts. Pelloxererts and fine-textured swamp soils may occur in depressions. In dissected areas, on basaltic rock, shallow Vertic Lithic Xerochrepts, Vertic Haploxerolls, and Lithic Haploxerolls occur on eroded slopes. Occasionally Xerofluvents cover the river banks.

The Xererts have an AC horizon sequence with heavy texture. The clay fraction consists of expanding clay minerals which cause the soil to crack badly during the alternating wet and dry seasons, and the soils show evidence of considerable churning action. The soils may contain calcium carbonate. Three structural horizons may be observed: an upper granular horizon, a columnar horizon, and a deeper bicuneate (polyhedric) horizon. The wedge-like faces are mostly at an angle of about 45 degrees to the horizon; slickensides are seen on these faces. Brown (Chromoxererts), and gray (Pelloxererts) types are distinguished. The Chromoxererts are found on better drained areas, while the Pelloxererts characterize undrained depressions. These soils formed either from fine-textured alluvial or eolian material or from basalt.

The dominant families of the soils of this map unit are fine, mixed, thermic and hyperthermic

These soils formed mainly from fine-textured alluvial or eolian sediments and from basalt in some places. These soils occur on level to gently sloping plains or undulating to rolling, moderately sloping low plateaus. The gradient of the slopes generally does not exceed 8%.

This association is typical of the great valleys, valley terraces and the eastern part of the coastal plain of central and northern Israel, as well as of the basaltic plateaus in this region.

J. Lithic Haploxerolls, Lithic Xerochrepts, Lithic Xerorthents and Lithic Xeropsamments (Pararendzinas).

This map unit has various combinations of Lithic Haploxerolls, Lithic

Xerochrepts, Lithic Xerorthents and Lithic Xeropsamments on most of the slopes. Coarse-textured dark brown Haploxeralfs also occur on moderate slopes. Light-colored, kurkaric, Xerofluvents with some Haploxerolls and Xerochrepts are found in the small depressions among the hills.

The Lithic Haploxerolls, Lithic Xerochrepts, Lithic Xerorthents and the Lithic Xeropsamments are shallow sandy or loamy, light brown to brown, calcareous soils with an AC horizon sequence on calcareous sandstone or on hardened lime crust overlying the calcareous sandstone.

The dominant family of the soils of this map unit is coarse-loamy, mixed, thermic.

These soils formed mainly from calcareous sandstone or calcrete (petrocalcic) that covers this sandstone. They are mainly on hilly ridges in the coastal plain area of Israel.

K. Vertic Haploxeralfs, Vertic Xerochrepts and Chromoxererts (Dark Brown).

In this map unit, the moderately sloping hills are covered mostly by Vertic Haploxeralfs, Vertic Xerochrepts and Chromoxererts. In the western part some of these soils are occupied by coarse-textured residual Haploxeralfs. Steep slopes are characterized by shallow Lithic Haploxerolls, Lithic Xerochrepts, Lithic Xerorthents, and Lithic Xeropsamments. In eroded and dissected areas fossil soils appear, and weather to form Typic Xerorthents and Calcic Rhodoxeralfs, residual Haploxeralfs, and Xererts. On transitions to the hilly area Lithic Haploxerolls may cover steep eroded slopes. Xerofluvent, Haploxeralfs and Xerochrepts, and alluvial Vertic Haploxeralfs, Vertic Xerochrepts and Chromoxererts are typical of the floodplains.

These Vertic Haploxeralfs, Vertic Xerochrepts and Chromoxererts generally have an ABBbca horizon sequence. The upper 10-20 cm. are brown, medium- to fine-textured (silty clay loam, clay loam, or silty clay) with a subangular blocky structure; with increasing depth the texture becomes finer (silty clay to clay) and the color darker. A ca horizon appears at a depth of 0.75-1.0 m. or even lower. The structure of the B horizon is prismatic. Clear cutans cover these prisms. Slickensides are usually found in the deeper layers and the soil cracks to some extent during the summer. The soil is calcareous throughout and developed from medium- to fine-textured unconsolidated eolian or alluvial sediments.

The dominant families of the soils of this map unit are fine-loamy and fine silty, mixed, thermic and hyperthermic.

These soils are formed mostly from fine eolian sediments, coastal sand, calcareous sandstone (kurkar), and medium- to fine-textured alluvial deposits. The soils occur on level to gently sloping plains or undulating to rolling, moderately sloping low plateaus. Some of the plateaus and hills are severely dissected by erosion, and here slopes may reach up to 30-40%.

This association is typical of the Pleshet plain as well as of some valleys in the semiarid zone, and in the transition to the arid zone in Israel.

L. Calcixerollic Xerochrepts, Typic Calciorthids, and Cambic Gypsiorthids (Calcareous Serozems).

This association includes Calcixerollic Xerochrepts, Typic Calciorthids, Cambic Gypsiorthids, Aquic Calciorthids, Typic Haplaquepts and Aeric Haplaquepts on the level topography while Lithic Torriorthents with some Aridic Lithic Haploxerolls cover the steep eroded areas. In the lower Jordan Valley the Calcixerollic Xerochrepts, Typic Calciorthids, and Cambic Gypsiorthids are usually highly saline and gypsiferous. Various Xerofluvents, Haploxerolls, Xerochrepts and Salorthids are found along the Jordan floodplain.

The Calcixerollic Xerochrepts, Typic Calciorthids and Cambic Gypsiorthids are deep, highly calcareous grayish-brown, medium- to fine-textured ABCca or ABcaCcs soils, developed from calcareous lacustrine sediments. They are often gypseous or even saline at depth.

The dominant family for the soils of this map unit is fine-loamy, mixed, hyperthermic.

These soils are derived from chalky and marly lake sediments and travertine. The soils of the Jordan floodplains were formed from recent alluvial sediments. The area includes distinct river and lake terraces. The topography of the terraces is level. The Jordan floodplain is included in this association.

This association occupies the central and lower Jordan valley.

M. Lithic Torriorthents, Aridic Lithic Haploxerolls, Calcic Haploxeralfs and and Calcixerollic Xerochrepts (Brown Lithosols and Loessial Arid Brown).

This association consists mainly of steep, rocky and eroded slopes. Lithic Torriorthents and Aridic Lithic Haploxerolls are found in the pockets among the rocks, while Lithic Torriorthents with some Aridic Lithic Haploxerolls characterize the steep eroded slopes, from which the Nari crust has been stripped off. Calcic Haploxeralfs and Calcixerollic Xerochrepts are found on flat hilltops, plateaus, footslopes and on terraces in the large valleys. Xerofluvents with some Haploxerolls and Xerochrepts occupy narrow valleys. Young Typic Torrifluvents and Typic Xerofluvents are found in depressions.

The Lithic Torriorthents and Aridic Lithic Haploxerolls are shallow soils with an AC horizon sequence. They are pale brown to yellowish-brown or brown, loamy and calcareous. The hard parent rock or a hardened calcareous crust is found at 20-30 cm. depth or even less. The transition to the rocks is mostly sharp. Many rock outcrops are found, usually at the surface; the soil is restricted to the pockets among these rocks.

The Calcic Haploxeralfs and Calcixerollic Xerochrepts have an ABcaC or ABcaBb horizon sequence. The A horizon is yellowish-brown and relatively coarse-textured (mainly very fine sandy loam), and the structure is subangular blocky to massive. The B horizon is darker and somewhat finer (loam to clay loam) and has soft lime concretions. The Bca horizon has a pronounced subangular blocky or blocky or even a prismatic structure and sometimes there are clay skins on ped surfaces. Soft lime nodules are found in this horizon. The soil is calcareous throughout. The deeper layers consist of either brown clay or yellowish-brown loam. The parent material is eolian and redeposited loess.

The dominant families of the soils of this map unit are coarse-loamy and fine-loamy, mixed, thermic and hyperthermic.

These soils are formed mainly from underlying rock which may be chalk, marl, limestone or conglomerate, most of which is covered by a hard lime crust. Most of the soils are affected by loessial dust which is deposited mainly on flat or moderately sloping areas, and even on quite steep north-facing slopes. The soils occur in a hilly and mountainous region. The mountain slopes are generally quite steep, with fairly large valleys between them. Undulating plateaus alternate with strongly dissected areas.

N. Calcic Haploxeralfs and Calcixerollic Xerochrepts (Loessial Arid Brown).

In this association, the moderate slopes are covered mostly by Calcic Haploxeralfs and Calcixerollic Xerochrepts. Calcic Haploxeralfs, Vertic Haploxeralfs, Vertic Xerochrepts, Chromoxererts and clayey Typic Xerorthents with some Typic Torriorthents are found on steep eroded slopes in the western part of the region. In the foothill region stony Haploxeralfs and Lithic Torriorthents and Aridic Lithic Haploxerolls may cover steep slopes. Young loessial soils are found in floodplains and depressions.

The Calcic Haploxeralfs and Calcixerollic Xerochrepts have an ABcaC or ABcaBb horizon sequence. The A horizon is yellowish-brown and relatively coarse-textured (mainly very fine sandy loam), and the structure is subangular blocky to massive. The B horizon is darker and somewhat finer (loam to clay loam) and has soft lime concretions. The Bca horizon has a pronounced subangular blocky or blocky or even a prismatic structure and sometimes there are clay skins on ped surfaces. Soft lime nodules are found in this horizon. The soil is calcareous throughout. The deeper layers consist of either brown clay or yellowish-brown loam. The parent material is eolian and redeposited loess.

The dominant families of the soils of this map unit are fine-loamy, mixed, thermic and hyperthermic.

These soils are mainly formed in loessial sediments. In eroded areas, parent material may be sand (in west) or gravel, conglomerates and chalk (in the east). This association is found on level to undulating, gently sloping plateaus as well as on dissected plateaus with locally hilly topography. Areas of river terraces are also included.

P. Typic Haplargids and Typic Camborthids (Alluvial Arid Brown).

In this association, Typic Haplargids and Typic Camborthids, mostly saline, cover most of the area. Stony Haplargids and Camborthids may be found on higher terraces. Various Xerofluvents, with some Haploxerolls and Xerochrepts, Haplaquents and Salorthids are found in depressions and near river beds.

The Typic Haplargids and Typic Camborthids have an ABC or ABBb horizon sequence. The A horizon is brown and usually loamy. The B horizon is somewhat darker and somewhat finer-textured. The structure of this horizon is usually blocky or prismatic and clay coatings are quite common. Lime spots or mycelia may be found in this layer. Many of these soils are saline. The soils are calcareous throughout. The parent material consists of calcareous, medium- to fine-textured alluvium.

The dominant family for the soils of this map unit is fine-loamy, mixed, hyperthermic.

These soils are formed mainly from calcareous silty and clayey alluvial material. Near the mountains, limestone gravel and stones may occur. These soils occur on ancient, nearly level alluvail fans and plains overlying lacustrine terraces.

This association is restricted to the lower Jordan Valley.

Q. Salorthids (Solonchaks).

This association includes various Salorthids. The texture ranges from sand to clay; all the soils suffer from a high water table and some of them are extremely saline, with up to 50% salts in the upper horizons.

The Salorthids are soils with considerable amounts of salts (mainly NaCl), especially in the upper layers; The pH is usually below 8.5. They are formed from recent alluvial material where saline groundwater seasonally comes close to the surface. Sandy, loamy and clayey types are recognized.

The dominant families of the soils of this map unit are sandy, coarse-loamy, fine-loamy, and fine, mixed, hyperthermic.

These soils form mainly from recent alluvail deposits ranging in texture from sand to clays. The soils occupy the central part of low lying, terminal drainage valleys and closed basins, where the groundwater table is near the soil surface.

These soils occur mainly in the Arava Valley and around the Dead Sea. They may also occupy small areas in other climatic regions, especially close to the sea coast.

R. Typic Haplargids (Loessial Serozems).

In this map unit, Typic Haplargids, somewhat saline, are typical of plateaus and moderate slopes. The steep slopes are characterized by coarse-textured and stony Haplargids and Camborthids, and even by Lithic Torriorthents and Aridic Lithic Haploxerolls. Young loessial soils (Torrifluvents) are found in depressions and floodplains. Stony Haplargids and Camborthids are found also on plains, terraces and plateaus, especially in the drier parts of the area. Loamy, highly calcareous Xerofluvents are found in the Yehuda Desert and the lower Jordan Valley.

The Typic Haplargids have an ABcaBb or ABcaC horizon sequence. The A horizon is yellowish-brown or very pale brown and relatively coarse-textured (mainly very fine sandy loam); the structure is subangular blocky. The B horizon is darker, usually brown and finer (loam to clay loam). The structure of this horizon is subangular blocky or prismatic, with many lime nodules. The soil is calcareous throughout and saline in the deeper layers. The parent material is eolian and redeposited loess.

The dominant families for the soils of this map unit are coarse-loamy and fine-loamy, mixed, thermic and hyperthermic.

These soils are formed mainly from loessial sediments and some sandy sediments and gravel. Highly calcareous loamy sediments are also parent material in the Yehuda Desert and lower Jordan Valley. This association occupies level to undulating, gently sloping plateaus, as well as dissected plateaus with locally hilly topography. Areas of river terraces are also included.

This association is typical for the Be'er Sheva' plain and adjacent areas. Small areas among the Negev hills and mountains, in the Yehuda Desert and lower Jordan Valley.

S. Lithic Torriorthents, Aridic Lithic Haploxerolls and Typic Haplargids (Brown Lithosols and Loessial Serozems).

In this association, shallow Lithic Torriorthents and Aridic Lithic Haploxerolls with numerous rock outcrops are typical of the steep hillslopes. Lithic Torriorthents and Aridic Lithic Haploxerolls are found also on small plateaus. Inclusions of Typic Haplargids are found in broad valleys, terraces, and on large plateaus. Typic Torrifluvents (loessial and stony) cover narrow valleys.

The Lithic Torriorthents and Aridic Lithic Haploxerolls are shallow soils with an AC horizon sequence. They are pale brown to yellowish-brown or brown, loamy and calcareous. The hard parent rock or a hardened calcareous crust is found at 20-30 cm. depth or even less. The transition to the rocks is mostly sharp. Many rock outcrops are found, usually at the surface; the soil is restricted to the pockets among these rocks.

The Typic Haplargids have an ABcaBb or ABcaC horizon sequence. The A horizon is yellowish-brown or very pale brown and relatively coarse-textured (mainly very fine sandy loam); the structure is subangular blocky. The B horizon is darker, usually brown and finer (loam to clay loam). The structure of this horizon is subangular blocky or prismatic, with many lime nodules. The soil is calcareous throughout and saline in the deeper layers. The parent material is eolian and redeposited loess.

The dominant families for the soils of this map unit are coarse-loamy and fine-loamy, mixed, thermic and hyperthermic.

The parent material for these soils is mainly chalk, Nari lime crust, limestone, dolomite and flint. Small plateaus and valleys are often covered by eolian and redeposited loess. Most of the area consists of steep mountain slopes. Some plateaus and moderate slopes occur near the summits and water divides. Many small and moderately broad valleys dissect the land.

This association is typical of most of the hilly and mountainous desert steppe of the northern and central Negev; large areas also in the Yehuda Desert.

T. Quartzipsamments, Typic Torripsamments, Xeric Torripsamments, Calcic Haploxeralfs and Xerochrepts (Sandy Regosols and Arid Brown).

In this map unit, shallow (0.5-1.5 m) young sandy deposits cover almost the whole landscape. Quartzipsamments, Typic Torripsamments, Xeric Torripsamments cover buried sandy soils and various Calcic Haploxeralfs and Xerochrepts. These are found on the moderately sloping lands in the northern part of the area, while in depressions the sand is somewhat deeper (1-2 m) and covers silty loess deposits. In the south, Typic Torrifluents and Typic Xerofluvents are either covered by, or mixed with, the Quartzipsamments, Typic Torripsamments and the Xeric Torripsamments.

The Quartzipsamments, Typic Torripsamments and Xeric Torripsamments are coarse sandy soils with an undeveloped profile, which were formed by eolian and fluvial deposition in arid areas.

The dominant family for the soils in this map unit is thermic.

These soils are formed from sandy deposits; loessial deposits, mixed partly with sand, formed the paleosols (buried soils) and the soils of the depressions in the southern part of the area. The association occupies low, undulating to moderately sloping hills, with broad depressions and valleys. In the southern part it characterized alluvial valleys among the dunes.

This association is typical of the southernmost part of the coastal plain of Israel, as well as of alluvial valleys among the dunes of the northern Negev and northeastern Sinai.

V. Sand Dunes

Most of the area in the map unit consists of shifting sand dunes and sandy plains.

The dominant family is thermic.

The parent material is unconsolidated dune sand. The dune phase occupies the level to gently rolling, moderately dissected coastal area. The dunes have a gentle windward and steep slipface characteristic of transverse dunes and may reach a height of 15-20 m. Dune belts on the coast vary in width from a few hundred meters to several kilometers. The shifting dunes in the Negev are long seif dunes alternating with strips of fixed sand.

This association covers noncontinuous accumulations of coastal sand along the Mediterranean coast. Another area includes the inland dunes in the western Negev.

W. Typic Xerorthents and Typic Torriorthents (Regosols).

In the map unit, various Typic Xerorthents with some Typic Torriorthents cover the steep eroded slopes. Young Xerofluvents are found on lower terraces and in the gully bottoms. Some well differentiated soils may be found on moderate slopes, especially at the edge of the badlands. Shallow calcareous Lithic Torriorthents or Aridic Lithic Haploxerolls cover the steep eroded slopes and badlands that characterize the terrace escarpments in the Jordan Valley.

The Typic Xerorthents and Typic Torriorthents have an AC horizon sequence. The parent material includes various paleosols, ancient alluvial and eolian sediments, or volcanic scoria and tuffs. The soils are quite variable in texture and color. They are characteristic of eroded areas, badlands or young eroded volcanic cones and stabilized dunes.

These soils form from sand, clays, loess, old soils (Typic Rhodoxeralfs) and marl. These soils are in a badland topography. The badlands along rivers include a strip between the higher Pleistocene terrace and the recent lower terraces and floodplains. The badlands in the upland areas are more complex; here may be distinguished the dissected steep peripheral areas which are still being eroded and the central area where the slopes are more moderate.

The dominant families for the soils of this map unit are coarse-loamy and fine-loamy, mixed, thermic and hyperthermic.

The badlands occur along the terrace escarpments in the Jordan Valley and near the Besor River. Deeply dissected upland area in the southern part of the coastal plain.

X. Bare Rocks and Lithic Torriorthents (Desert Lithosols).

Most of the areas in this map unit consist of bare rocky mountain slopes. Shallow Cambic Gypsiorthids and Petrogypsic Gypsiorthids with some Camborthids are typical of small plateaus and moderately sloping water-divides. Shallow Lithic Torriorthents are found as inclusions on soft calcareous sediments. Coarse Typic Torrifluvents and Typic Torripsamments occur in narrow valleys.

The Lithic Torriorthents are very shallow, light-colored, highly calcareous and saline loamy soils that cover chalk or marls in extremely arid areas.

The dominant families for the soils of this map unit are coarse-loamy and fine-loamy, mixed, thermic and hyperthermic.

These soils formed from hard limestone, dolomite, chalk and flint. Small areas of various magmatic rocks also occur. Most of the area exhibits uncovered steep slopes. Some small plateaus occur, mainly on top of mountain crests, water-divides and mesas. The area is dissected by many dry valleys, some of which are quite large.

This association is typical of the hilly and mountainous area of the extremely arid southern desert of Israel, east and south of the main water-divide.

Y. Cambic Gypsiorthids, Petrogypsic Gypsiorthids, Typic Torrifluvents and Typic Torripsamments (Reg and Coarse Desert Alluvium).

Cambic Gypsiorthids and Petrogypsic Gypsiorthids are typical for the level plateaus in this map unit. The slopes are characterized by various sediments, mainly stony debris, while stony and gravelly Typic Torrifluvents and Typic Torripsamments occupy the valleys and fans. Locally, silty Xerofluvents are found in depressions.

The Cambic and Petrogypsic Gypsiorthids and Camborthids are shallow calcareous desert soils covered by a gravelly desert pavement. The A horizon is loamy, very pale brown, vesicular, 2-8 cm. thick; the B horizon is 10-20 cm, thick, light reddish-yellow, somewhat finer-textured, loose and very saline. At greater depth there are stones and weathered rocks. Gypsum crystals or petrogypsic horizons are found in the deeper soil layers. These soils were formed under extremely arid conditions from various parent materials, principally limestone, flint and chalk, or from coarse desert alluvium.

The Typic Torrifluvents and Typic Torripsamments are coarse materials deposited in wide stream beds and in alluvial fans, in various parts of the desert. These deposits are stony and contain very little fine soil material between the stones.

The dominant families for the soils of this map unit are fine-loamy and loamy-skeletal, mixed, hyperthermic.

These soils formed mainly from mixed stony, mainly unconsolidated, debris. The association occupies level plateaus and plains as well as dissected low plateaus. It characterizes also large valleys and alluvial fans.

This association is typical for the valleys and plains in the extreme south of Israel (Sinai, the southern Negev, and the Arava Valley).

Z. Typic Torrifluvents and Typic Xerofluvents (fine-grained Desert Alluvial).

This map unit is mainly fine-grained Typic Torrifluvents and Typic Xerofluvents.

The Typic Torrifluvents and Typic Xerofluvents are very pale brown or light yellowish-brown, fine sandy or silty, stone-free soils, devoid of profile development, calcareous or highly calcareous and sometimes slightly saline. They comprise the recent wind- and water-transported silty and fine sandy sediment.

The dominant families for the soils of this map unit are sandy and coarse-silty, mixed, hyperthermic.

The parent material is fine sandy and silty desert alluvium. The landforms are closed endoreic depressions and broad dry river-bottoms with negligible gradient.

The Arava Valley, Nahal El-Arish and its tributaries in the Sinai are the main locations of this unit. Some closed endoreic depressions occur in the Desert of Paran.

Yuma Map Unit Descriptions

1. Gilman (Typic Torrifluvent)-Vint (Typic Torrifluvent)-Brios (Typic Torrifluvent) Association.

This association occupies the floodplains of the Gila and Colorado Rivers as well as the floodplains and lower alluvial fans along many of the major intermittent drainages throughout the county. Proportions of the soils vary from place to place with the Gilman (Typic Torrifluvent) and Vint (Typic Torrifluvent) dominant along the Colorado and Gila Rivers and the coarser textured soils along tributaries. Slopes are dominantly 0 to 2 percent. The soils are more than 60 inches deep and are formed in recent alluvium from mixed igneous and sedimentary rocks.

Gilman (Typic Torrifluvent) soils make up about 40 percent of the unit, Vint (Typic Torrifluvent) soils 20 percent and Brios (Typic Torrifluvent) soils 20 percent. Of the remainder, about 15 percent consists of intermixed areas of Typic Torrifluvents and about 5 percent Riverwash in the stream channels, water areas, and marshy areas along the Colorado and Gila Rivers.

Gilman soils typically have a surface layer 6 to 18 inches thick of pale brown loam underlain to 60 inches or more by stratified pale brown to brown loam, very fine sandy loam and silt loam. Local areas of these soils are slightly to strongly saline. Vint soils typically have profiles of pale brown and brown loamy fine sand that is stratified with thin layers of very fine sandy loam, silt loam, and fine sand. Brios soils have a surface layer of pale brown or brown sandy loam or loamy sand 7 to 16 inches thick over stratified coarse sand, gravelly sand and gravelly loamy sand to 60 inches or more. Slopes on all of these soils are generally less than 1 percent but range up to 2 percent on some of the low alluvial fans. All soils in this association are subject to brief periods of flooding, particularly on lands undeveloped for farming.

3. Harqua (Typic Haplargid)-Perryville (Typic Calciorthid)-Gunsight (Typic Calciorthid) Association.

This association occupies alluvial fans and valleys between the low mountains in the central part of the county north of the Gila River. Slope is dominantly 1 to 8 percent but short slopes up to 15 percent occur in places. The soils are generally more than 60 inches deep and are formed in old alluvium from andesitic tuffs, calcareous sedimentary rocks, and some granitic and basaltic rocks plus additions of volcanic ash and dust.

Harqua (Typic Haplargid) soils make up about 35 percent of the unit, Perryville (Typic Calciorthid) soils 25 percent, and Gunsight (Typic Calciorthid) soils 20 percent. The remaining 20 percent consists mainly of intermixed areas of Typic Calciorthids on the fans, small amounts of Typic Durorthids and Lithic Camborthids on included rocky areas, and Typic Torrifluvents along the drainageways.

Harqua soils tyically have a varnished appearing gravel pavement covering about 70 percent of the surface. This is underlain by a pinkish-white and light reddish brown gravelly clay loam layer 1/2 to 6 inches thick. The subsoil is a reddish brown grading to light reddish brown and pink gravelly

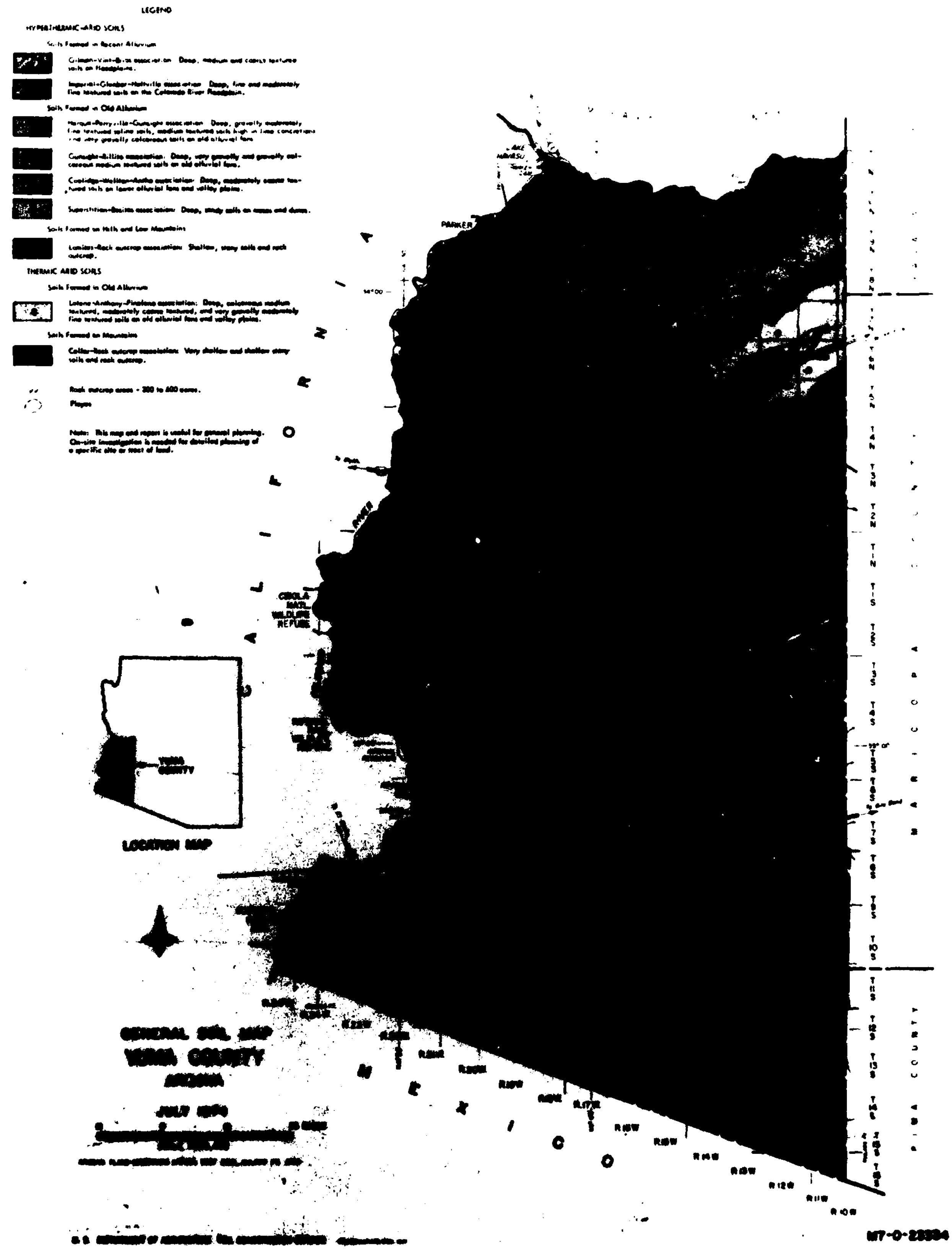

Figure 6. Soil Map of the Yuma Proving Grounds.

Table 12. Classification of the Soils at the Yuma Proving Grounds (Chamberlin and Richardson, 1974)

Series	Family	Subgroup
Antho	Coarse-loamy, mixed (calcareous), hyperthermic	Typic Torrifluvent
Brios	Sandy, mixed, hypethermic	Typic Torrifluvent
Cherioni	loamy-skeletal, mixed, nonacid, hyperthermic	Typic Durorthid
Coolidge	coarse-loamy, mixed, hyperthermic	Typic Calciorthid
Gachado	loamy-skeletal, miced, hyperthermic	Lithic Haplargid
Gilman	coarse-loamy, mixed (calcareous), hyperthermic	Typic Torrifluvent
Gunsight	loamy-skeletal, mixed, hyperthermic	Typic Calciorthid
Harqua	fine-loamy, mixed, hyperthermic	Typic Haplargid
Lomitas	loamy-skeletal, mixed, hyperthermic	Lithic Camborthid
Perryville	coarse-loamy, carbonatic, hyperthermic	Typic Calciorthid
Rositas	mixed, hyperthermic	Typic Torripsamment
Rillito	coarse-loamy, mixed, hyperthermic	Typic Calciorthid
Superstition	sandy, mixed, hyperthermic	Typic Torriorthent
Vint	sandy, mixed, hyperthermic	Typic Torrifluvent
Wellton	coarse-loamy, mixed, hyperthermic	Typic Haplargid

clay loam, mottled with lime and salt, about 20 to 30 inches thick. The substratum to 60 inches or more is light brown gravelly clay loam or gravelly loam with numerous pinkish white soft lime masses. The soils are saline and calcareous throughout the profile and range from moderately to very strongly alkaline. Harqua soils occur on the smoother portions of the lower valley slopes having gradients usually of less than 2 percent but ranging from 1 to 4 percent. Perryville soils have a scattering of gravel and cobblestones on the surface. The surface 8- to 14-inch layer is a very pale brown gravelly loam with the gravel consisting of about 20 percent gravel sized hard lime concretions. The underlying layers to about 40 inches are similar in color and texture but contain 20 to 35 percent gravel and gravel sized lime concretions by volume and average more than 40 percent $CaCO_3$ (lime). Below 40 inches, the profile ranges from sandy loam to very gravelly loam sand and contains less lime. These soils are on the upper fans and ridges extending out from the mountains. Slopes are 1 to 8 percent. Gunsight soils have a light brown very gravelly loam surface layer 1 to 4 inches thick underlain to 60 inches or more by pinkish-white, pink, and white very gravelly light loam or sandy loam. They are strongly calcareous throughout and contain many soft and hard, weakly cemented lime masses and lime coated gravel below the surface 10 inches. Gravel content averages 35 to 70 percent by volume. These soils are on the upper, shallowly dissected, fans having slopes mainly of 1 to 8 percent but with a few short side slopes of drainages up to 15 percent. The proportions of Perryville and Gunsight soils vary from place to place. Perryville soils are dominant near the Kofa, Castledome and New Water Mountains where volcanic and calcareous sedimentary rocks form much of the parent material. Gunsight soils are dominant where igneaous rocks form the major parent rock formation.

4. Gunsight (Typic Calciorthid)-Rillito (Typic Calciorthid) Association.

This association occurs on alluvial fans at the base of low mountains throughout the county composed mainly of gneiss, schist, and volcanic rocks that include basalt, andesite and tuffs. The soils are more than 60 inches deep and are strongly calcareous and gravelly. Slopes are mainly 1 to 8 percent.

Gunsight (Typic Calciorthid) soils make up about 50 percent of the unit and Rillito (Typic Calciorthid) soils 20 percent. The remaining 30 percent consists of intermixed areas of Typic Haplargids and Typic Calciorthids on the fans and Typic Torrifluvents along the drainageways. A few small bodies of rock outcrop and stony shallow soils are also included.

Gunsight soils have a light brown very gravelly loam surface layer 1 to 4 inches thick overlying pink to white and pinkish gray very gravelly loam and sandy loam to 60 inches or more. The substratum materials below about 10 inches are high in lime consisting of soft and hard masses, that may be weakly cemented, and with lime coatings on the gravels. Gravel content ranges from 35 to 70 percent by volume. These soils are on the upper dissected fans having slopes of 1 to 8 percent. A few areas are included that have short slopes into the drainageways of up to 15 percent. The Rillito soils have a light brown or light yellowish brown gravelly sandy loam surface layer 5 to 10 inches thick and pink, pinkish gray, and white gravelly sandy loam or fine sandy loam subsurface layers to 60 inches or more. Gravel content in the 10- to 40-inch zone averages from 15 to 35 percent by volume and they contain 15 to 30 percent

$CaCO_3$ consisting of soft and hard lime masses and gravel coatings. Some layers may be weakly cemented. These soils are on the lower fan slopes having gradients of 1 to 5 percent.

5. Coolidge (Typic Calciorthid)-Wellton (Typic Haplargid)-Antho (Typic Torrifluvent) Association.

This association occupies broad valleys between low mountain ranges. Most of the unit occurs south of the Gila River. The soils are more than 60 inches deep and are formed on old alluvium from a wide variety of rocks. Schist and granitic rocks are dominant but some basalt, andesite, tuffs, and calcareous sedimentary rocks are also included. Slopes are dominantly 0 to 2 percent but range up to 5 percent.

Coolidge (Typic Calciorthid) soils make up about 35 percent of the unit, Wellton (Typic Haplargid) soils, 25 percent, and Antho (Typic Torrifluvent) soils, 15 percent. The remaining 25 percent consists of intermixed areas of Typic Calciorthids on the uplands and moderately coarse and coarse-textured soils along the drainageways. A few low hills having rocky shallow soils are also within the unit.

Coolidge soils have a light yellowish brown calcareous sandyloam surface layer 6 to 14 inches thick. The underlying layer to about 25 inches is similar in color and texture but contains many fine white lime filaments. The substratum to 60 or more inches is pale brown sandy loam containing many white soft lime masses and averages more than 15 percent $CaCO_3$. These soils are on lower alluvial fans and valley plains with slopes of 0 to 2 percent. They included Rillito (Typic Calciorthid) soils are associated. Wellton soils typically have a light brown loamy sandy surface layer about 6 inches thick containing 10 to 20 percent fine gravel. The subsoil is light brown and yellowish red fine gravelly sandy loam to about 28 inches. From 28 to 60 inches or more is pink and light brown fine gravelly sandy loam with many soft white lime masses in the upper part. The soils commonly contain moderate amounts of soluble salt in the subsoil and substratum that readily leaches out of the root zone when the soils are irrigated. Slopes are 0 to 2 percent. Antho soils have a brown light sandy loam surface layer 1 to 8 inches thick. The underlying layer to 60 inches or more are light brown and light yellowish brown sandy loam. The profile contains 5 to 35 percent fine granitic gravel by volume throughout and may have thin strata ranging from silt loam to gravelly loamy sand. Anthony (Typic Torrifluvent) soils are on alluvial fans and along drainageways throughout the unit and have slopes of 0 to 5 percent.

6. Superstition (Typic Torriorthent)-Rositas (Typic Torripsamment) Association.

This association occurs mainly on the Yuma mesa. The soils are formed in old sandy alluvium that has been reworked in many places by wind to form hummocks and low dunes. In stabilized areas the slopes are 0 to 2 percent but dune areas have short slopees up to 20 percent.

Superstition (Typic Torriorthent) soils make up about 60 percent of the unit and Rositas (Typic Torripsamment) soils 20 percent. The remaining 20 percent includes intermixed Typic Haplargids and Typic Calciorthids. A few rocky buttes are also included and small areas of duneland and escarpments occur.

Superstition soils have a light brown loamy fine sand surface layer 3 to 18 inches thick. The underlying layer to 24 or 30 inches is similar in color and texture but contains a few soft and hard lime masses. The substratum below this is light brown to pink loamy fine sand with common to many soft and hard lime masses. $CaCO_3$ content decreases below depths of 40 or 50 inches. These soils are usually on the smoother portions of the plains or mesas and slopes are 0 to 8 percent. Rositas soils have a surface layer of light brown fine sand 1 to 10 inches thick. This is underlain by light brown fine sand to 60 inches or more that is cross-bedded, or thinly laminated with strata of loamy fine sand 1 to 5 mm thick. These layers cause lateral spreading of roots and water, particularly under cultivation. Slopes are basically 0 to 2 percent but hummocks and dunes up to 20 feet high have short slopes up to 20 percent.

7. Lomitas (Lithic Camborthid)-Rock Outcrop Association.

This association consists of the major mountain ranges throughout the area. The kinds of parent rocks are variable. In general schists, gneiss, and granites are dominant south of the Gila river except for low basaltic hills in the eastern and southeastern part. Scattered throughout this area are also calcareous sedimentary rocks. Slopes range from 5 percent on some of the low basalt hills to more than 60 percent on the rocky peaks.

Lomitas (Lithic Camborthid) soils and rock outcrop each make up about 35 percent of the unit. Two major inclusions are the Gachado (Lithic Haplargid) soils which make up about 12 percent of the unit and Cherioni (Typic Durorthid) soils, 8 percent. The remaining 10 percent consists mainly of assorted Typic Calciorthids and Typic Haplargids on small areas of included alluvial fans and narrow bands of moderately coarse and coarse textured soils and Riverwash along and in the drainageways.

Lomitas soils have a surface cover of 50 to 70 percent gravel, cobblestones, and stones. The 2- to 5-inch surface layer is brown very cobbly loam. The subsoil is light brown very gravelly loam that becomes more calcareous with depth. Bedrock is usually at depths of 12 to 20 inches. The soils are calcareous throughout and contain lime coatings on the rock fragments below the surface layer. Lomitas soils are formed mainly on granite, gneiss, schist, andesite or rhyolite-tuff, or tuff-conglomerate. Slopes are dominantly 5 to 40 percent. Rock outcrop is interspersed between soil areas as low ledges and escarpments but is mainly on the peaks and ridge crests forming the upper parts of the mountain ranges. Proportions of rock to soil vary from place to place and by rock types. Gachado soils have a brown very cobbly loam surface layer about 2 inches thick. The subsoil is yellowish red gravelly clay loam or sandy clay loam that becomes very gravelly and strongly calcareous below about 8 inches. Bedrock is a depths of 9 to 20 inches and includes parent rocks similar to those listed for the Lomitas series. The Gachado soils occur on the lower concave slopes, in saddles or on pediments. Slopes are dominantly 8 to 15 percent but range up to 20 percent. The Cherioni soils are usually on low basaltic hills and lava flows having slopes of 2 to 15 percent. Typically, Cherioni soils have a 50 percent surface cover of stones, cobblestones and gravel. The 1/2- to 3-inch surface layer is light brown gravelly very fine sandy loam. This is underlain by light brown strongly calcareous gravelly or very gravelly, very fine sandy loam 4 to 8 inches thick. The dominant characteristic of these soils is a 1- to 8-inch thick extremely hard silica-lime cemented hardpan at depths of 5 to 12 inches. This is underlain by basalt or related volcanic bedrock at depths from the surface of 6 to 20 inches but more often at 9 to 16 inches.

Fort Irwin Soil Map Unit Descriptions

AC. Anthony (Typic Torrifluvent)-Cajon (Typic Torripsamment)-Arizo (Typic Torriorthent) Association.

The Anthony soils make up about 40 percent of the unit, Cajon soils 40 percent and Arizo soils 20 percent.

Anthony soils are well drained soils >60 inches deep formed in alluvium. The surface is moderately alkaline, brown sandy loam and the subsoil is moderately alkaline, brown sandy loam. Available water holding capacity is 9 to 11 inches. Permeability is moderately rapid and runoff is medium.

Cajon soils are excessively drained soils >60 inches deep, formed in alluvium. The surface is moderately alkaline, light brownish gray, fine sand and the subsoil is moderately alkaline, light gray sand. Available water holding capacity is 4 to 5 inches. Permeability is rapid and runoff is slow.

Arizo soils are excessively drained soils >60 inches deep formed in alluvium. The surface is moderately alkaline, light brownish gray, very gravelly fine sand and the subsoil is moderately alkaline, light brownish gray, very gravelly sand. Available water-holding capacity is 2 to 4 inches. Permeability is very rapid and runoff is very slow.

AM. Adelanto (Xeralfic Haplargid)-Mojave (Typic Haplargid)-Garlock (Typic Haplargid) Association.

The Adelanto soils make up about 50 percent of the unit, Mojave soils 30 percent and Garlock soils 20 percent.

Adelanto soils are well drained soils >60 inches deep formed in alluvium. The surface is slightly acid, brown coarse sandy loam and the subsoil is moderately alkaline, reddish brown sandy loam. Available water holding capacity is 5 to 9 inches. Permeability is moderately rapid and runoff is medium.

Mojave soils are well drained soils >60 inches deep formed in alluvium. The surface is neutral, light yellowish brown sandy loam and the subsoil is moderately alkaline, brown clay loam. Available water holding capacity is 6 to 9 inches. Permeability is moderately slow and runoff is medium.

Garlock soils are well drained soils >60 inches deep formed in alluvium. The surface is moderately alkaline, yellowish brown loamy sand and the subsoil is moderately alkaline, brown sandy clay loam. Available water holding capacity is 2 to 4 inches. Permeability is moderately slow and runoff is medium.

BI. Badland.

This map unit is 100 percent badland. The area is rough and actively eroding. Parent materials are mixed. Permeability is slow and runoff is very rapid.

BO. Barstow (Typic Haplargids)-Oban (Typic Natrargid) Association.

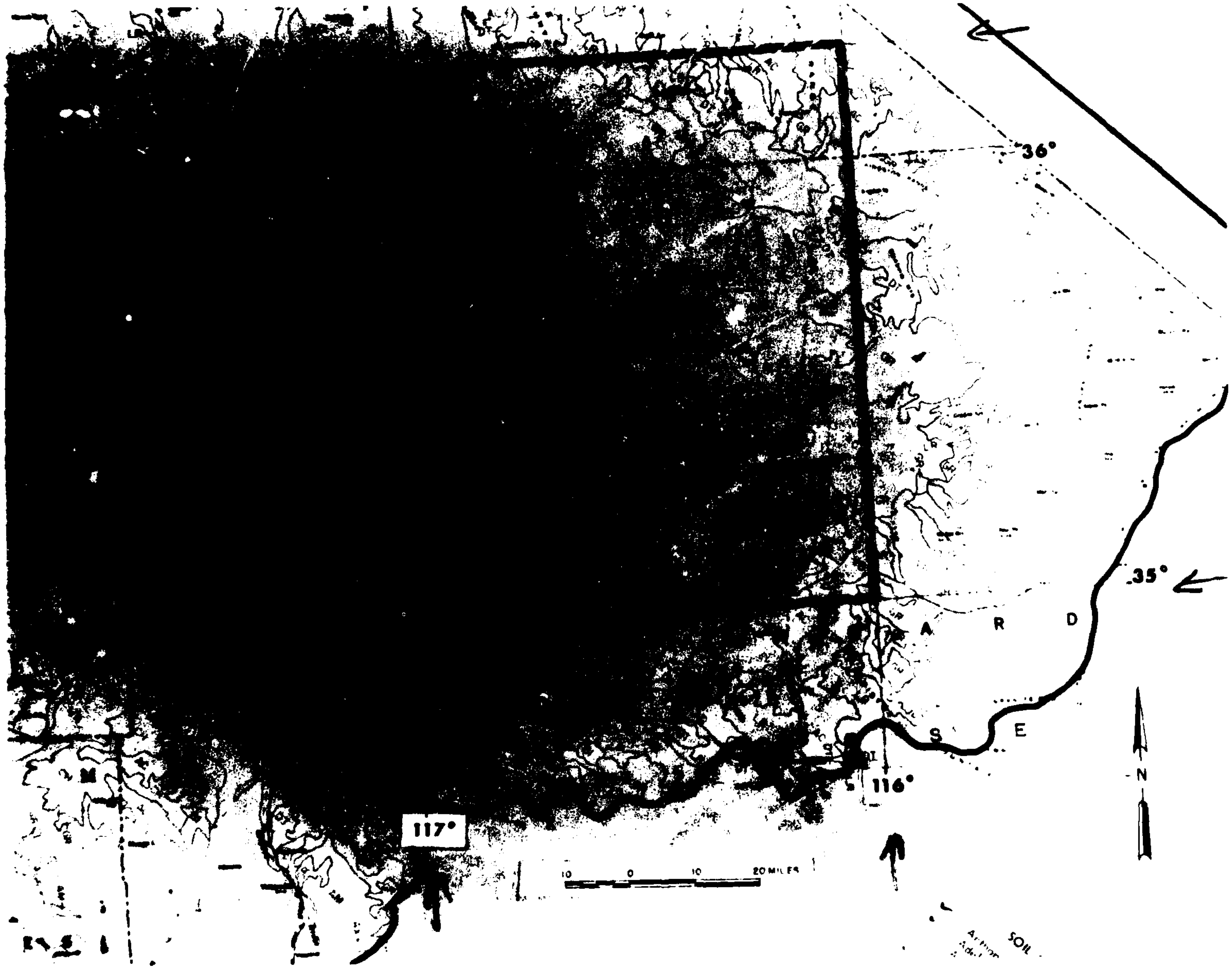

Figure 7. Soil Map of Fort Irwin, California Area.

Table 13. Classification of the Soils at Fort Erwin (Soil Survey Staff, 1976)

Series	Family	Subgroup
Adelino	fine-loamy, mixed, thermic	Typic Camborthid
Anthony	coarse-loamy, mixed (calcareous), thermic	Typic Torrifluvent
Arizo	sandy-skeletal, mixed, thermic	Typic Torriorthent
Barstow	coarse-loamy, mixed, thermic	Typic Haplargid
Bitter Spring	loamy-skeletal, mixed, thermic	Typic Haplargid
Brazito	mixed, thermic	Typic Torripsamment
Cajon	mixed, thermic	Typic Torripsamment
Calvista	loamy, mixed, thermic	Lithic Camborthid
Canutio	loamy-skeletal, mixed (calcareous), thermic	Typic Torriorthent
Cinco	mixed, thermic	Xeric Torripsamment
Garlock	fine-loamy, mixed, thermic	Typic Haplargid
Hi Vista	fine-loamy, mixed, thermic	Typic Haplargid
Land	fine-silty, mixed, thermic	Typic Salorthid
Mohave	fine-loamy, mixed, thermic	Typic Haplargid
Oban	fine, montmorillonitic, thermic	Typic Natrargid
Rosamond	fine-loamy, mixed (calcareous), thermic	Typic Torrifluvent
Tonopah	sandy-skeletal, mixed, thermic	Typic Calciorthid
Vinton	sandy, mixed, thermic	Typic Torrifluvent

The Barstow soils make up about 40 percent of the unit, Oban soils 30 percent and undifferentiated soils about 30 percent.

Barstow soils are well drained soils >60 inches deep formed in alluvium. The surface is moderately alkaline, light yellowish brown gravelly sand and the subsoil is moderately alkaline, light reddish brown sandy loam. Available water holding capacity is 3 to 4 inches. Permeability is moderate and runoff is slow.

Oban soils are moderately well drained soils >60 inches deep formed in alluvium. The surface is modrately alklaine, light yellowish brown fine sandy loam and the subsoil is very strongly alkaline, pale brown clay loam. Available water holding capacity is 7 to 9 inches. Permeability is slow and runoff is very slow.

CH. Calvista (Lithic Camborthid)-Hi Vista (Typic Haplargid)-Cinco(Typic Torripsamment) Association.

The Calvista soils make up about 60 percent of the unit, Hi Vista soils about 30 percent and Cinco about 10 percent.

Calvista soils are well drained soils 14 to 20 inches deep formed on granite. The surface is moderately alkaline, pale brown sandy loam and the subsoil is moderately alkaline, light yellowish brown sandy loam. Available water holding capacity is 1 to 3 inches. Permeability is moderately rapid and runoff is medium.

Hi Vista soils are well drained soils 20 to 40 inches deep formed on granite. The surface is neutral, light yellowish brown loamy fine sand and the subsoil is mildly alkaline, reddish brown sandy clay loam. Available water holding capacity is 4 to 6 inches. Permeability is moderately slow and runoff is medium.

Cinco soils are excessively drained soils >60 inches deep formed on granite. The surface is moderately alkaline, brown very gravelly loamy sand and the subsoil is moderately alkaline, brown gravelly loamy sand. Available water holding capacity is 3 to 5 inches. Permeability is rapid and runoff is medium.

DT. Canutio (Typic Torriorthent)-Tonopah (Typic Calciorthid)-Bitter Spring (Typic Haplargid) Association.

The Canutio soils make up 60 percent of the unit, Tonopah soils 20 percent and Bitter Springs soils 20 percent.

Canutio soils are well drained soils 40 to 60 inches deep formed in alluvium. The surface is moderately alkaline, pale brown gravelly sandy loam and the subsoil is moderately alkaline, pale brown very gravelly sandy loam. Available water holding capacity is 2 to 4 inches. Permeability is moderate and runoff is rapid.

Tonopah soils are excessively drained soils >60 inches deep formed in alluvium. The surface is moderately alkaline, light brown cobbly sandy loam and the subsoil is strongly alklaline, light brown very gravelly sand. Available water holding capacity is 1 to 2 inches. Permeability is very rapid and runoff is slow.

Bitter Spring soils are well drained soils >60 inches deep formed in alluvium. The surface is strongly alkaline, pink loam and the subsoil is strongly alkaline, light reddish brown sandy clay loam. Available water holding capacity is 2 to 4 inches. Permeability is moderately rapid and runoff is medium.

GR. Granite Rockland.

This map unit is 100 percent granite rockland. Permeability is rapid and runoff is medium to rapid.

LR. Lava Rockland.

This map unit is 100 percent lava rockland. Runoff is rapid.

RL. Rosamond (Typic Torrifluvent)-Land (Typic Salorthid)-Playas Association.

The Rosamond soils make up about 20 percent of the unit, Land soils 20 percent, and Playas 60 percent.

Rosamond soils are well drained soils >60 inches deep formed in alluvium. The surface is mildly alkaline, brownish gray fine sandy loam and the subsoil is moderately alkaline, pale brown silty clay loam. Available water holding capacity is 9 to 12 inches. Permeability is moderate and runoff is medium.

Land soils are moderately well drained soils >60 inches deep formed in alluvium. The surface is strongly alkaline, grayish brown silty clay and the subsoil is strongly alkaline, light brownish gray silty clay. Available water holding capacity is 1 to 5 inches. Permeability is moderately slow and runoff is slow.

Playas are closed basins containing poorly drained lacustrine sediments. Permeability is slow and they are often ponded.

VB. Vinton (Typic Torrifluvent)-Brazito (Typic Torripsamment)-Duneland Association.

The Vinton soils make up about 30 percent of the unit, Brazito soils 40 percent and duneland 30 percent.

Vinton soils are well drained soils >60 inches deep formed in alluvium. The surface is mildly alkaline, brown loamy sand and the subsoil is moderately alkaline, yellowish brown loamy sand. Available water holding capacity is 4 to 6 inches. Permeability is moderately rapid and runoff is slow.

Brazito soils are well drained soils >60 inches deep formed in alluvium. The surface is moderately alkaline, grayish brown sandy clay loam and the subsoil is moderately alkaline, light gray sand. Available water holding capacity is 3 to 5 inches. Permeability is rapid and runoff is slow.

Duneland is excessively drained shifting sand dunes >60 inches deep. Permeability is rapid and runoff is slow.

Fort Huachuca Soil Map Unit Descriptions

A3. Karro (Ustollic Calciorthid) Association.

This association consists of deep, well-drained, limy soils with medium and moderately fine textured surfaces and underlying layers. The underlying layers have more than 40 percent calcium carbonate. Slopes range from 0 to 15 percent. Available water holding capacity is 11 to 12 inches. Intake rates are moderate, permeability is moderate to moderately slow, and surface runoff is slow to medium.

C2. White House (Ustollic Haplargid)-Tubac (Typic Paleargid)-Forrest (Ustollic Haplargid) Association.

This association consists of deep, well-drained, nearly level to hilly, reddish brown, fine textured soils with medium and moderately coarse textured surfaces, fine textured subsoils and moderately fine to moderately coarse textured substrata. The subsoil and substrata may contain 20 to 30 percent gravel. All of these soils have lime accumulations at moderate depths. Slopes are 0 to 30 percent. Available water holding capacity is 7.5 to 10.5 inches. Intake rate is moderate and permeability is slow. Surface runoff is medium.

D4. Graham (Lithic Argiustoll)-Lampshire (Lithic Haplustoll) Association.

This association consists of shallow and very shallow, dark-colored, moderately steep to steep, cobbly and gravelly soils over andesitic and rhyolitic bedrock. The Graham soils have gravelly and cobbly fine textured subsoils and bedrock within 20 inches. Lampshire soils have very cobbly and gravelly loam surfaces and underlying material with bedrock at 20 inches or less. Slopes are 15 to 30 percent. This association occurs on isolated cone-shaped hills or on hills bordering the steeper mountain ranges. Available water holding capacity is 1 to 2 inches. Intake rate is moderate, permeability is moderate to slow, and surface runoff is medium to rapid.

E3. Tortugas (Lithic Haplustoll) Association.

This association consists of shallow and very shallow, dark-colored, steep to very steep, cobbly and stony loams over limestone bedrock. The bedrock is within 20 inches of the surface. Rock outcrop makes up 20 to 35 percent of the unit. There are also areas of deep cobbly and gravelly soils in the canyons. Slopes are 30 to 60 percent or more. This association occurs in the higher mountain ranges. Available water holding capacity is 1.0 to 2.5 inches. Intake rate and permeability is moderate. Surface runoff is medium to rapid.

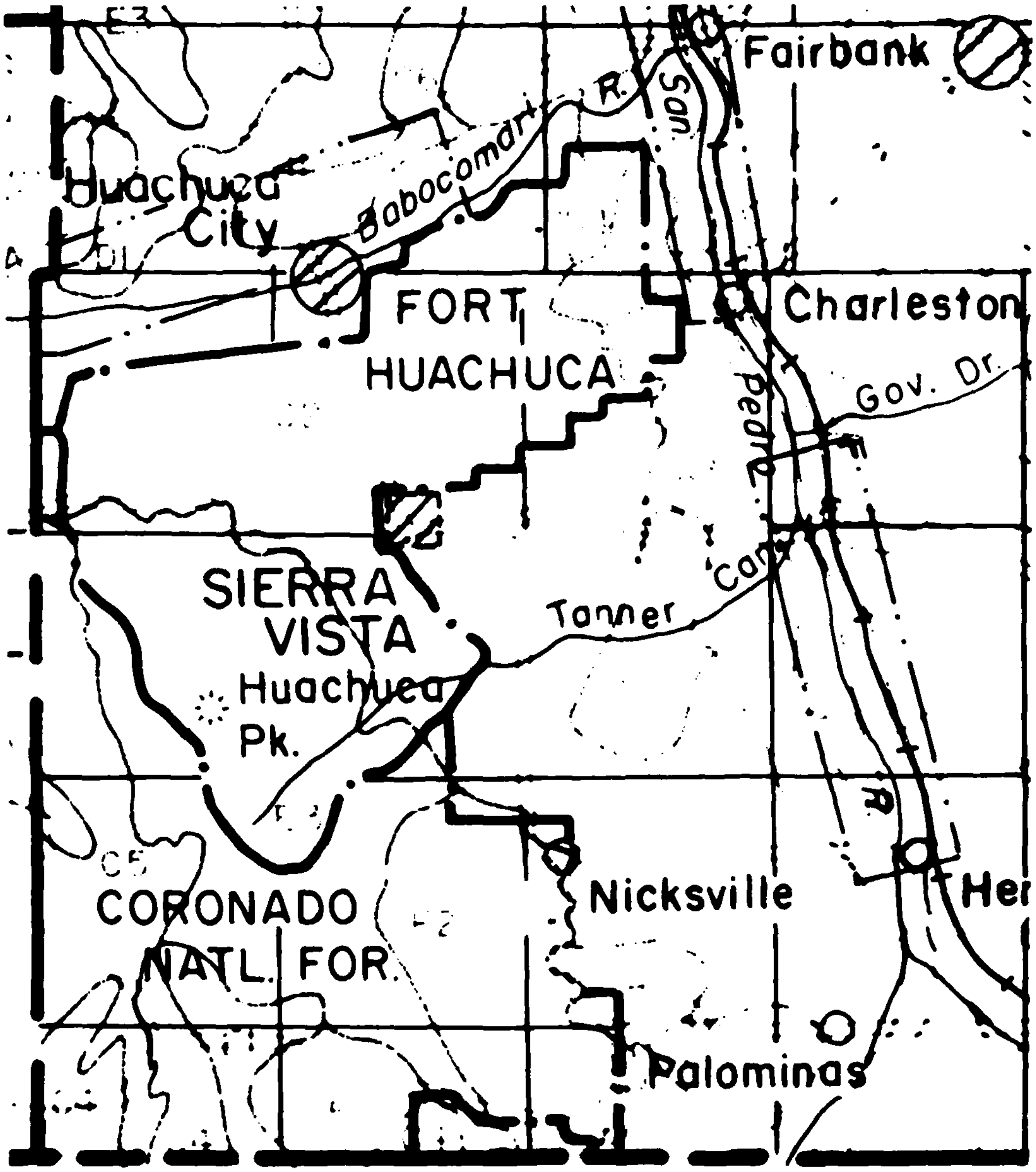

Figure 8. Soil Map of Fort Huachuca, Arizona.

Table 14. Classification of the Soils at Fort Huachuca (Richmond, 1971 and Richardson et al, 1979)

Series	Family	Subgroup
Barderville	loamy, mixed, mesic, shallow	Udorthentic Haplustoll
Bernardino	fine, mixed, thermic	Ustollic Haplargid
Bonita	fine, montmorillonitic, thermic	Typic Chromustert
Caralampi Var.	loamy-skeletal, mixed, thermic	Ustollic Haplargid
Chiricahua	clayey, mixed, thermic, shallow	Ustollic Haplargid
Fanno	fine, illitic, mesic	Udic Haplustalf
Faraway	loamy-skeletal, mixed, mesic	Lithic Haplustoll
Forrest	fine, mixed, thermic	Ustollic Haplargid
Gaddes	fine-loamy, mixed, mesic	Ustollic Haplargid
Graham	clayey, montmorillonitic, thermic	Lithic Argiustoll
Guest	fine, mixed (calcareous), thermic	Typic Torrifluvent
Hathaway	loamy-skeletal, mixed, thermic	Aridic Calciustoll
Hogris	loamy-skeletal, mixed, nonacid, mesic	Typic Ustorthent
Karro	fine-loamy, carbonatic, thermic	Ustollic Calciorthid
Kimbrough	loamy, mixed, thermic, shallow	Petrocalcic Calciustoll
Lampshire	loamy-skeletal, mixed, thermic	Lithic Haplustoll
Luzena Variant	fine, montmorillonitic, mesic	Udic Argiustoll
Mabray	loamy-skeletal, carbonatic, thermic	Lithic Haplustoll
Pima	fine-silty, mixed, thermic	Anthropic Torrifluvent
Telephone	loamy-skeletal, mixed, nonacid, mesic	Lithic Ustorthent
Tortugas	loamy-skeletal, carbonatic, mesic	Lithic Haplustoll
Tubac	fine, mixed, thermic	Typic Paleargid
White House	fine, mixed, thermic	Ustollic Haplargid

37. Calciorthids-Paleorthids.

The Typic Calciorthids, which occupy 35 percent of the association, are characterized by their light-colored calcareous surface layers and subsurface layers with high lime content at shallow to moderate depths. These soils generally have thin surface layers of pale brown or light brownish-gray calcareous gravelly sandy loam or gravelly loam. The subsoil is a light brown gravelly or very gravelly loam. This layer grades to white very gravelly and weakly cemented caliche at depths of 15 to 25 inches. The lime content and cementation decrease with depth in contrast to the coarse fragments, which usually increase in size and amount with depth. Small areas of Typic Calciorthids throughout this association contain less gravel or coarse fragments. These soils commonly occupy the gently sloping side slopes and lower parts of the piedmont slopes where they merge with the drainageways. They have sandy loam or sandy clay loam surface layers over strongly calcareous sandy clay loam subsoils with soft to weakly cemented caliche occurring at a depth of about 20 to 40 inches.

The Typic Paleorthids, which constitute 35 percent of this association, consist mainly of light-colored, very shallow and shallow soils underlain by indurated caliche within a depth of 20 inches. The underlying caliche, which is laminar and strongly cemented in the upper 6 to 12 inches typically becomes less hard with depth. The surface layers are moderately coarse- to medium-textured and range in gravel content from about 10 or 15 percent to more than 35 percent. These surface layers are typically calcareous, but they may range from slightly calcareous to strongly calcareous.

Also of limited extent in this association are Typic Haplargids and Torriorthentic Haplustolls. The Typic Haplargids constitute about 10 percent of the area and occur on the less sloping landscapes. They usually have surface layers of gravelly sandy loam or gravelly sandy clay loam over a reddish-brown gravelly clay loam with a moderate to high content of lime in the lower part. This is underlain by a pinkish-white limy, very gravelly loam. Some small areas of Typic Haplargids contain little or no gravel. These soils typically have sandy loam surface layers and sandy clay loam subsoils over pinkish-white loams with a high content of lime.

The Torriorthentic Haplustolls, which occur on the upper slopes along fronts dominated by igneaous rocks, have moderately dark-colored, noncalcareous, gravelly loamy sand or gravelly sandy loam surface layers and moderately coarse-textured underlying layers. Also in this association are small areas of miscellaneous land types, such as Rough Broken Land, Alluvial Land, and Riverwash.

Representative soil series are: Nickel, Tencee, Delnorte, Upton, Turney, Dona Ana, and Aladdin.

39. Paleargids-Torripsamments-Paleorthids.

The Typic Paleargids, which comprise 35 percent of the association, are moderately deep over a strongly cemented lime zone that begins at depths ranging from about 20 to 40 inches below the surface. They occupy nearly level

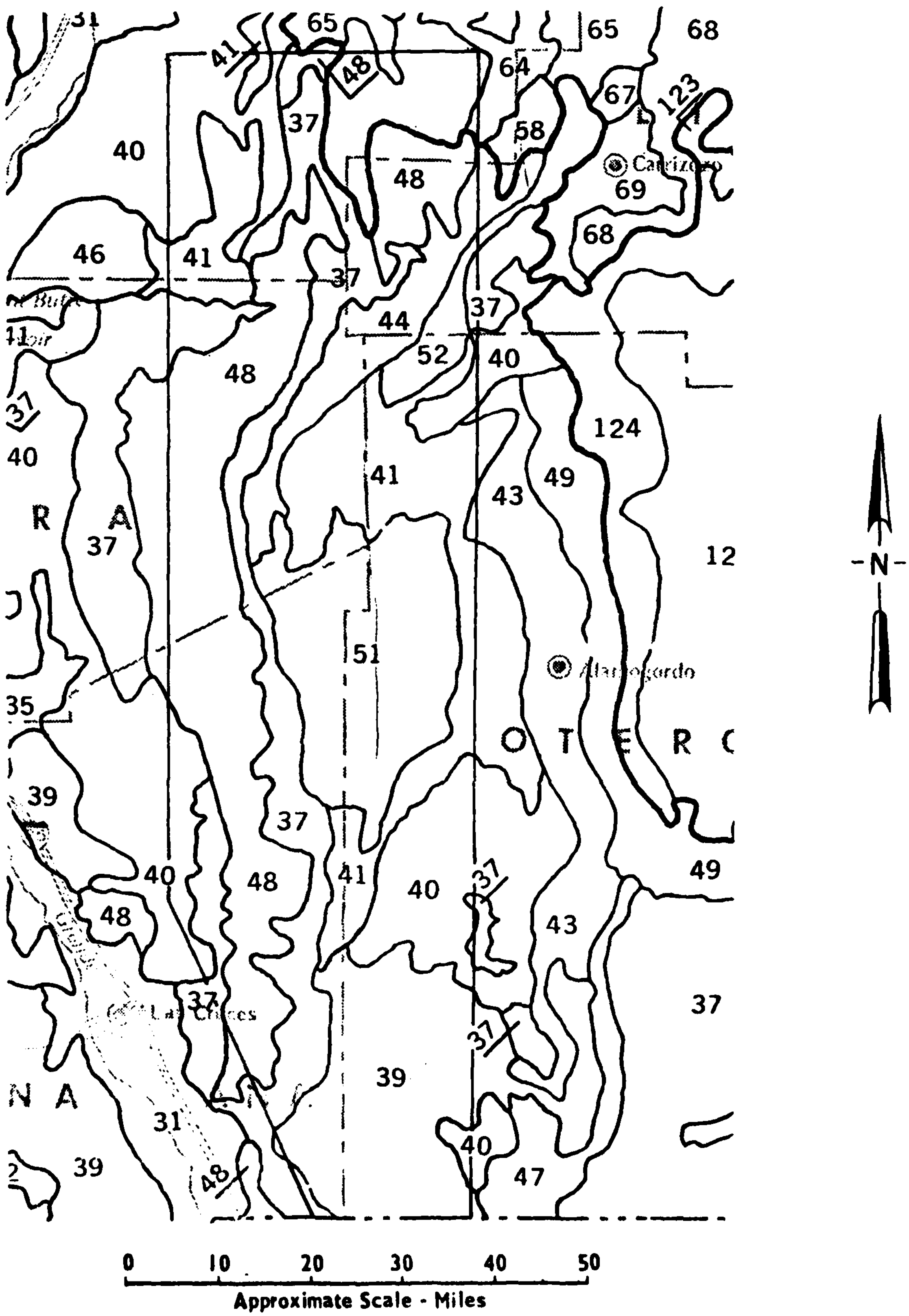

Figure 9. Soil Map of the White Sands Missile Range, New Mexico.

Table 15. Classification of the Soils at White Sands Missile Range (Neher and Bailey, 1976)

Series	Family	Subgroup
Aladdin	coarse-loamy, mixed, thermic	Torriorthentic Haplustoll
Alica Variant	fine-loamy, mixed, mesic	Typic Camborthid
Berino	fine-loamy, mixed, thermic	Typic Haplargid
Bluepoint	mixed, thermic	Typic Torripsamment
Deama	loamy-skeletal, carbonatic, mesic	Lithic Calciustoll
Dona Ana	fine-loamy, mixed, thermic	Typic Haplargid
Gilland	Loamy-skeletal, mixed, thermic	Ustollic Camborthid
Glendale	fine-silty, mixed (calcareous), thermic	Typic Torrifluvent
Holloman	fine-loamy, gypsic, thermic, shallow	Typic Torriorthent
La Fonda	fine-loamy, mixed, mesic	Ustollic Camborthid
Lozier	loamy-skeletal, carbonatic, thermic	Lithic Calciorthid
Marcial	fine, illitic, thermic	Typic Camborthid
Mead	fine, mixed, thermic	Typic Salorthid
Mimbres	fine-silty, mixed, thermic	Typic Camborthid
Nickel	loamy-skeletal, mixed, thermic	Typic Calciorthid
Onite	coarse-loamy, mixed, thermic	Typic Haplargid
Oscura	fine, mixed (calcareous), thermic	Ustic Torrifluvent
Pajarito	coarse-loamy, mixed, thermic	Typic Camborthid
Pinaleno	loamy-skeletal, mixed, thermic	Typic Haplargid
Pinaleno Variant	loamy-skeletal, mixed, thermic	Ustollic Haplargid
Rance Variant	fine-loamy, mixed, thermic, shallow	Typic Torriorthent
Russler	fine-silty, mixed, thermic	Typic Camborthid
Sonoita	coarse-loamy, mixed, thermic	Typic Haplargid
Sotim	fine-loamy, mixed, thermic	Typic Calciorthid
Tencee	loamy-skeletal, carbonatic, thermic, shallow	Typic Paleorthid
Ubar	fine, mixed, thermic	Typic Camborthid
Wink	coarse-loamy, mixed, thermic	Typic Calciorthid
Yesum	coarse-loamy, gypsic, thermic	Typic Gypsiorthid

to very gently sloping landscapes and are most common some distance from the escarpments. These soils typically have thin noncalcareous sandy loam or loamy sand surface layers over subsoils that range from fine sandy loam to sandy clay loam. Reddish-brown is the dominant color above the pinkish-white or white strongly cemented lime layer. The laminar and indurated part of this caliche layer normally is confined to the upper 6 to 24 inches. In many of the interdune areas, the thin surface layer has been removed by wind erosion.

The Typic Torripsamments account for 20 percent of this association and occupy the coppice dunes and those parts of the association that have gently rolling or duned topography. Commonly, the dunes are from 4 to 6 feet high and are forming in and around mesquite bushes and other shrubs. These soils have surface layers of loose, noncalcareous to weakly calcareous brown to reddish-brown fine sand over thick deposits of fine sand, which often grade into sandy loam or sandy clay loam near the bottom of the dune.

The Typic Paleorthids, which are shallow over indurated caliche, occur on nearly level to very gently sloping landscapes occupying about 15 percent of this association. These soils typically have light brown or pale brown calcareous surface layers. The subsurface layers, which are similar in color and texture, commonly contain a few angular caliche fragments. These are underlain at a depth of less than 20 inches by pinkish-white indurated caliche which is strongly cemented in the upper 6 to 12 inches and becomes less cemented with depth.

In addition to these three major soil groups, there are also in this general soil area Typic Calciorthids, Typic Haplargids, and Typic Camborthids. The Typic Calciorthids, which constitute 15 percent of the total area, commonly occupy the lower or slightly depressional areas in this association and are the most extensive of these inclusions. These soils are characterized by calcareous loamy fine sand or fine sandy loam surface layers and moderately coarse-textured subsoils over soft caliche. The underlying lime layer or caliche ranges from noncemented to weakly cemented, and usually occurs at a depth of 20 to 40 inches. Occasionallly, however, it is as shallow as 10 inches. The Typic Haplargids in this unit have loamy sand or sandy loam surface layers and well developed sandy clay loam subsoils. These are underlain at moderate depths by pinkish-white soil layers with a high content of lime or by medium- to moderately coarse-textured soil layers with only small to moderate accumulations of lime. The typic Camborthids are deep and have only weakly developed subsoils. Those with loamy fine sand surface layers and sandy loam subsoils and substrata are the most common. There is usually some segregated lime in the form of fine seams and small soft masses in the lower part of the subsoil and upper part of the substratum.

Representative soils series are: Cacique, Hueco, Cruces, Pintura, Simona, Wink, Berino, and Pajarito.

40. Haplargids-Torripsamments.

Typic Haplargids, which constitute 50 percent of this association, commonly occur on the gently sloping and undulating landscapes. A few low hummocks occasionally occur around shrubs where erosion has been active. In much of this unit, they occupy the gently undulating areas between the dunes and rolling ridges occupied by the deep sands. These soils have a thin surface layer of light brown to light reddish-brown noncalcareous fine sandy loam or loamy fine sand over thick reddish-brown sandy clay loam subsoil. The lower part of the subsoil, which is normally calcareous, contains a few filaments and small soft masses of lime. This is generally underlain at depths of 3 to 4 feet by a pinkish-white sandy clay loam that is very high in lime. Occasionally, the soils are underlain by high lime layers at depths of 20 to 36 inches, and these soils are frequently calcareous to the surface. Approximately 20 percent of the Typic Haplargids in this general soil area have rapidly permeable and moderately coarse-textured subsoils. The substratum of these soils usually consists of sand or loamy sand; however, strata of gravelly sand may occur occasionally below a depth of about 3 feet.

The Typic Torripsamments occur on the coppice dunes and those parts of this association that are gently rolling and duny. They have surface layers of loose, noncalcareous to weakly calcareous brown or reddish-brown fine sand over thick deposits of fine sand. The soils are deep and very susceptible to wind erosion.

Soils of the Typic Calciorthid, Typic Gypsiorthid, Typic Paleorthid, and Typic Torrert subgroups are also in this association. The Typic Calciorthids are characterized by their calcareous surface layers and strongly calcareous subsoils and substrata. A major part of this subgroup has loamy fine sand or fine sandy loam surface layers, fine sandy loam, or sandy clay subsoils, and pinkish-white or white soil layers with a high content of lime at depths of about 10 to 40 inches. These lime layers are occasionally weakly cemented. A small acreage of Typic Calciorthids, which occur on the nearly level basin floors, are medium- to moderately fine-textured. These soils consist mainly of silt loams, silty clay loams, and clay loams to a depth of 60 inches or more. Filaments and small soft masses of lime commonly occur below an average depth of about 2 feet. The Typic Gypsiorthids are gypsiferous, calcareous, and moderately coarse- to medium-textured. The soils layers below a depth of 6 to 20 inches may contain 50 to 75 percent or more of gypsum. The Typic Paleorthids consist mainly of loamy fine sands and fine sandy loams underlain by undurated caliche within 20 inches of the surface. The Typic Torrerts, which occupy low positions and swales, are deep and fine-textured.

Representative soil series are: Berino, Dona Ana, Onite, Pintura, Bluepoint, Wink, Jal, Turney, Yesum, and Simona.

41. Gypsiorthids-Torriorthents-Gypsum Land.

The Calcic Gypsiorthids consist of shallow to moderately deep soils with thin pale brown calcareous loam surface layers. These layers grade through a light-colored strongly calcareous clay loam to the underlying gypsiferous earth at depths of 20 to 36 inches. They are moderately to strongly saline in localized areas where drainage is restricted, and in this unit, they usually occupy gently sloping plains or the slightly depressed and swale-type landscapes.

The Typic Gypsiorthids have less lime and more gypsum in the surface layers than the Calcic Gypsiorthids. They are light-colored and moderately coarse- to medium-textured to a depth of 60 inches or more. The gypsum content in the surface layer usually ranges from about 25 to 50 percent, increases to approximately 75 to 80 percent within 10 to 20 inches, and then gradually decreases with depth.

The Typic Torriorthents, which make up 25 percent of the association, commonly occur on low ridges and very gently undulating landscapes. They are thin light-colored gypsiferous and calcareous soils underlain by thick beds of gypsum at a depth of 6 to 20 inches.

Gypsum Land, which accounts for 20 percent of this soil association, consists of a complex of outcrops of gypsiferous earth or rocks and very shallow soils. The gypsiferous materials vary from white "chalky" earths to hard, light-colored, crystalline gypsum rocks. A thin mantle of loamy soil material may occur in small areas between the outcrops of gypsiferous earth or rock.

The remaining parts of this association consist dominantly of Typic Camborthids. Typic Calciorthids, Typic Paleorthids, and Saline Alluvial Land. The Typic Camborthids in this unit commonly occur as relatively small areas in swales and low-lying positions where they are susceptible to the accumulation of salts. They range in texture from medium to fine and are commonly slightly to moderately saline and gypsiferous. The Typic Calciorthids, which occupy nearly level to gently sloping plains and terraces, usually have moderatelv thick calcareous loam surface layers over moderately fine-textured subsoils and substrata. The Typic Paleorthids are shallow and loamy soils underlain by indurated caliche within a depth of 20 inches.

Representative soil series are: Reeves, Yesum, Holloman, Ryussler, Marcial, Reakor, and Upton.

43. Calciorthids-Camborthids.

The Typic Calciorthids, which account for 35 percent of the association, are deep, calcareous, weakly developed, and moderately permeable. The surface layer is usually a light brownish-gray loam, but it may range from loam to silty clay loam. The subsoil is typically a light brown clay loam, but may also range in texture from a heavy loam to a silty clay loam. The substratum to a depth of 60 inches or more is dominantly moderately fine-textured. Filaments and small soft masses of lime commonly occur below an average depth of 28 inches.

The Typic Camborthids, which comprise 30 percent of this association, usually occur on the lower parts of the piedmont slopes adjacent to the basin floor. They are characterized by their reddish-brown color and the presence of gypsum crystals within a depth of 40 to 50 inches. These soils have a thin surface layer of light brown to reddish-brown calcareous silt loam or loam over a reddish-brown calcareous silty clay loam or clay loam subsil. The underlying substrata are also typically medium to moderately fine-textured to a depth of 50 to 60 inches or more. Gypsum crystals, which usually increase with depth, are common in the lower part of the subsoil and in the substratum. Salinity typically ranges from slight to moderate.

The Typic Torriorthents occupy the gently sloping plains and alluvial fans adjacent to arroyos or intermittent drainages. They consist mainly of soils with thin, calcareous loam or silt loam surface layers and weakly stratified medium to moderately fine-textured subsurface layers to a depth of

5 feet or more. Although dominantly light reddish-brown or reddish-brown, they are quite variable in color and include some that range from pale brown or light brownish-gray to brown. They are susceptible to water erosion where the vegetative cover is depleted and there is a concentration of runoff. A few deep gullies, particularly in the drainageways, are common.

Calcic Gypsiorthids, which are widely distributed throughout the association on gently sloping and undulating landscapes, are underlain at depths of 20 to 40 inches by gypsiferous earths. The soil layers above the gypsum or gypsiferous earths are light-colored, strongly calcareous and medium- to moderately fine-textured. Also occurring to a limited extent, and commonly associated with the Calcic Gypsiorthids, are shallow soils underlain by gypsiferous earth within a depth of 20 inches.

The only other shallow soils of significance in this unit are those with calcareous gravelly loam or gravelly sandy loam surface layers over pinkish-white caliche or very gravelly loam with a very high lime content. These limy soil layers are often weakly cemented in the upper part and generally occur at a depth ranging from 10 to 25 inches. Miscellaneous land types, such as Gullied Land and Alluvial Land also comprise small acreages.

Representative soil series are: Reakor, Russler, and Reeves.

44. Camborthids-Calciorthids.

The Typic Camborthids comprise 65 percent of the association. They occur dominantly on nearly level to very gently sloping landscapes with slope gradients that usually average less than one percent. They have a surface layer of strongly calcareous silt loam or silty clay loam over a strongly calcareous silty clay or heavy silty clay loam subsoil. This grades through soil of similar color and texture to the underlying gypsiferous lacustrine material at depths ranging from 40 to 60 inches. The subsurface layers commonly contain fine threads and specks of lime as well as crystals of gypsum and other salts. Although salinity generaly varies from slight to moderate, about 20 percent of these soils is strongly saline. Also included are phases of these soils that have gypsum strata at depths of 20 to 40 inches. Colors are variable and may range from light brown or light yellowish-brown to reddish-brown. Small areas of these soils occupy the gently sloping swales and narrow valley bottoms on the piedmont slopes. They have loamy surface layers and moderately fine-textured subsoils and substrata, and they usually are not as saline and gypsiferous as those on the nearly level basin floors.

The Typic Calciorthids, which comprise 15 percent of the association, occupy the piedmont slopes on the outer fringes of this association. Slope gradients average between 1 and 5 percent. They have a thin surface layer of reddish-brown calcareous loam or clay loam which is underlain by a thick reddish-brown calcareous clay loam subsoil that commonly contains a few small soft masses of lime in the lower part. Below an average depth of 50 inches these soils typically become coarser-textured with textures ranging from gravelly sandy loam to gravelly loam or loam.

Less extensive soils include those of the Typic Salorthid, Typic Torriorthent, and Typic Gypsiorthid subgroups. The Typic Salorthids are deep, poorly drained, and saline. They usually have medium-textured surface layers and stratified subsurface layers that are moderately fine- to fine-textured. The Typic Torriorthents and Typic Gypsiorthids, which are developing over thick beds of gypsum or gypsiferous earths, commonly occur on ridges or on the more undulating landscapes in this association. The Typic Gypsiorthids consist of light brown gypsiferous very fine sandy loam or fine sandy loam to a depth of 60 inches or more. The gypsum content ranges from about 25 to 80 percent with highest concentrations typically occurring between 10 and 20 inches. The Typic Torriorthents in this association consist of light-colored, medium-textured soils underlain within a depth of 20 inches by thick beds of gypsum.

Representative soil series are: Marcial, Ubar, Sotim, Mead, Holloman, and Yesum.

47. Calcirothids-Rock Land-Paleorthids.

The Calciorthids, which are dominant in this general area, are principally in the Lithic and Typic subgroups. These comprise 25 percent and 20 percent of the association, respectively.

The Lithic Calciorthids are extensive on the moderately steep lower slopes and on the rolling limestone hills and upland ridges. They have a thin surface layer of light brownish-gray calcareous stony loam. This is underlain by a light yellowish-brown to light brown very strongly calcareous very stony loam. A thin layer of calcium carbonate accumulation in the form of soft masses and nodules occurs immediately above the limestone bedrock which is usually encountered at a depth of 6 to 20 inches.

The Typic Calciorthids, which are light-colored, calcareous, and shallow to moderately deep, occur on the gently to strongly sloping alluvial fans and piedmont slopes. Those near the base of the hills and mountains on the more steeply sloping and undulating landscapes usually have a thin surface layer of light brown or light brownish-gray calcareous gravelly sandy loam over a subsoil of light brown strongly calcareous very gravelly loam. This grades to a pinkish white caliche or very gravelly loam with a very high content at a depth of 15 to 25 inches. This is commonly weakly cemented in the upper part, and the lime content and cementation decreases with depth. Coarse fragments usually increase in size and amount with depth. Associated with these soils on the less sloping landscapes are moderately deep soils with calcareous very fine sandy loam, loam, or silt loam surface layers and strongly calcareous heavy loam or light clay subsoils. A few pebbles usually occur on the surface. The substratum below a depth of about 20 to 36 inches is a pinkish-white to white massive light clay loam containing much lime and some gravel.

Limestone Rock Land, a miscellaneous land type, comprises 25 percent of this association. It consists of a complex of shallow soils and outcrops of limestone with an occasional thin strata of other types of sedimentary rocks. The rock outcrops commonly occur as vertical or nearly vertical exposures and ledges. Small areas and pockets of moderately deep to deep soils are interspersed with the shallow soils and rock outcrops. These are commonly stony and medium-textured. Numerous stones and angular fragments of limestone are also common on the surface.

The Typic Paleorthids account for 20 percent of the association and generally occupy the gently sloping crests of ridges and fans. These soils have a thin surface layer of light brown to pale brown calcareous very gravelly loam or gravelly loam. This layer grades through soil of similar color and texture that contains numerous fragments of caliche to the underlying indurated caliche at a depth of 6 to 20 inches. The caliche layer, which is laminar and strongly cemented in the upper 6 to 18 inches, typically becomes less hard with depth.

Typic Camborthids, Typic Torriorthents, and Alluvial Land comprise a small acreage in this general soil area. Typic Camborthids, which usually occur in swales and gently sloping areas, are deep and medium- to moderately fine-textured. The Typic Torriorthents, moderately coarse to medium in texture, are usually gravelly or cobbly. Strata of gravel or cobble may occur below a depth of 3 to 4 feet.

Representative soil series are: Lozier, Nickel, Delnorte, Tencee, and Mimbres.

48. Rock Land-Haplargids.

Rock Land, a miscellaneous land type, constitutes 45 percent of this association. It is a complex of very shallow soils and rock outcrops. The bedrock usually occurs as vertical or nearly vertical exposures and ledges. In many parts of this unit, a large amount of loose rock occurs on the surface. A thin mantle of cobbly or stony soil material commonly occurs between the outcrops of bedrock. Although the intermingled soils are dominantly shallow, small areas of moderately deep and deep soils occur as pockets among the rock outcrops and ledges. These small areas of soil interspersed with the rock outcrops are highly variable; their characteristics are greatly influenced by the type of rock from which the parent material are weathered. For example, those forming in materials weathered from granite and monzonite are usually moderately coarse-textured and gravelly; those developing in materials from limestone are commonly medium- to moderately fine-textured and cobbly.

The Haplargids, which constitute 20 percent of the area, commonly occur on rolling to hilly and moderately steep landscapes and are dominantly in the Lithic subgroup. These soils usually have thin moderately coarse- and medium-textured surface layers over finer-textured, moderately well developed subsoils. The texture of the subsoils is mainly moderately fine and fine but may range from medium to fine. The surface and upper subsoils are typically noncalcareous. Gravel, cobble, and stones frequently occur in both surface and subsoil layers. The depth to bedrock is generally between 10 and 20 inches, but some may be moderately deep.

Lithic Argiustolls and Lithic Torriorthents are also of importance in this general soil area. The Lithic Argiustolls, which constitute 10 percent of the association, are similar to the Lithic Haplargids, but have darker surface layers. They usually occur on north and east aspects, or at higher elevations, where more precipitation is received or where the moisture is more effective. The Lithic Torriorthents, which comprise 15 percent of this association, are forming generally in materials weathered from limestone or other sedimentary rocks. These soils, which are also extensive on the moderately steep and rolling to hilly landscapes, lack distinct pedogenic horizons or well developed subsoils. They are dominantly moderately coarse to moderately fine-textured and generally gravelly, cobbly, or stony.

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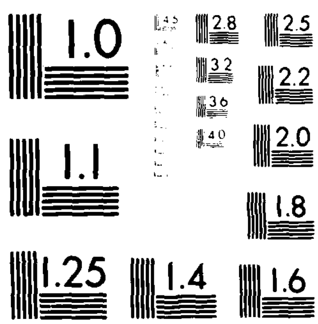

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963-A

Typic Calciorthids, Typic Paleorthids, Torriorthentic Haplustolls, and other miscellaneous land types, none of which are extensive, comprise most of the remaining parts of this general soil area.

Representative soil series are: Lehmans, Lozier, Gilland, and Latom.

51. Gypsum Land.

The Gypsum Dune Land or those areas occurring on undulating to rolling and duny land forms consist of almost pure gypsum sands. The source of the gypsum sand is believed to be from the closed basins and intermittent lake areas adjacent to the dunes. Winds have picked up the gypsum crystals from these basin floor areas and carried them in an easterly direction, building up the present dunes. The dunes, generally void of vegetation, shift and erode continually during windy periods. Gypsum Land, the other major component of this association, occupies the nearly level basin floor. Large basin floor areas are dominant in the western and southwestern parts of this general soil area. The surface is very smooth and nearly level except for the outer perimeter that is occasionally dissected with rills and shallow gullies formed by runoff from the adjacent higher landscapes. It consists of gypsiferous earth and gypsum deposits over lacustrine sediments. The thickness of gypsum over the underlying lacustrine sediments ranges from about 1 foot along the outer margins of the basin area to over 5 feet near the center. The area is barren except for scattered iodinebushes where the gypsum is about 2 to 3 feet over lacustrine materials with a shallow watertable.

52. Lava Rock Land.

The basalt rock covering this area is slow to weather, so the entire area is practically devoid of soil. The small pockets of soil that occur are extremely variable. They range in depth from shallow to deep, and in texture from stony sandy loams to heavy clay loams.

64. Calciorthids-Haplargids.

The Calciorthids, which comprise approximately 45 percent of this association, are dominantly in the Ustollic (25 percent) and Lithic Ustollic (20 percent) subgroups. The Ustollic Calciorthids are mainly on gently to strongly sloping valley side slopes. They consist dominantly of soils with light brown or grayish-brown, calcareous loam surface layers. The subsoil is similar, except that it contains more lime and is slightly lighter colored. A pinkish-white very limy loam commonly occurs at a depth of about 15 to 20 inches. The lime content decreases slightly below a depth of 30 to 36 inches. Small acreages of Ustollic Calciorthids are coarser-textured and are underlain by limestone bedrock at moderate depths. These soils usually have a calcareous loamy fine sand or fine sandy loam surface layer over moderately coarse-textured subsoils that commonly contain 10 to 30 percent angular fragments of limestone. The Lithic Ustollic Calciorthids are located on the moderately steep and rolling ridges and low hills that occur throughout this association. They are characterized by their brown or grayish-brown calcareous channery loam surface layer which grades through soil of similar texture that becomes lighter colored and more limy with depth. The light brown to pinkish-white channery loam subsurface layer rests abruptly on partly weathered, fractured limestone bedrock at a depth of 10 to 20 inches.

The Ustollic Haplargids, 30 percent of this association, commonly occur on gently to strongly sloping uplands and piedmont slopes at the base of hills and ridges. These soils normally have a surface layer of brown to light brown noncalcareous fine sandy loam or loam over a thick subsoil of brown to reddish-brown clay loam or sandy clay loam that is noncalcareous in the upper part. A few threads and small soft masses of lime are common in the lower subsoil. This is usually underlain by a pinkish-white very limy loam or sandy loam at depths of 40 to 50 inches. Although the Ustollic Haplargids are dominantly deep, a small acreage of these is underlain by sandstone bedrock at moderate depths. Surface layers and subsoils are like those of the other Ustollic Haplargids in this unit.

Also in this association are deep and medium-textured Ustollic Camborthids, deep and medium- to moderately fine-textured Cumulic Haplustolls, and shallow Ustollic Paleorthids. The Ustollic Paleorthids are medium-textured and are underlain by indurated caliche. In addition to these soils, approximately 10 percent of this association consists of miscellaneous land types including steep Rock Land, Gypsum Land, and Alluvial Land. Steep Rock Land occurs generally on mesa breaks, escarpments, and side slopes of ridges. It consists of a complex of shallow soils and outcrops of bedrock, with sandstone and limestone being the most extensive. Gypsum Land is less steep and consists of a complex of outcrops of gypsiferous earth or rocks and shallow soils. Alluvial Land occupies arroyo and drainage bottoms or flood plains, and consists of highly stratified soil materials extremely variable in texture.

Representative soil series are: Harvey, Chupadera, Pinon, Penistaja, Witt, Hagerman, Manzano, and Pastura.

65. Camborthids-Torriorthents-RockLand.

The Ustollic Camborthids, characterized by weakly expressed pedogenic horizons, occur on gently to strongly sloping and undulating piedmont surfaces or fans and occupy 40 percent of the association. Those on the crests and side slopes of the low ridges or fans are the most extensive and consist of soils with reddish-brown, calcareous loam surface layers. These layers grade to a subsoil, about 8 to 20 inches thick, of light reddish-brown heavy loam. The lower part of the subsoil is usually more limy and coarser-textured than the upper part. This is underlain by a light reddish-brown strongly calcareous loam that commonly contains many small soft masses and fine threads of lime. In the swales and on the lower parts of the piedmont, these sois are also deep, with reddish-brown, weakly calcareous loam surface layers, but they have finer-textured clay loam and silty clay loam subsoils and substrata that typically contain a few specks and threads of lime.

The Lithic Ustic Torriorthents, which comprise 25 percent of the association, are shallow, light-colored, gently to strongly sloping soils developing dominantly on sandstone mesas and breaks. They have thin surface layers of light brownish-gray to light brown sandy loam or gravelly sandy loam which grade through a pale brown to light yellowish-brown calcareous gravelly sandy loam or sandy loam to the underlying sandstone bedrock at depths ranging from 8 to 20 inches. The coarse fragments in the soil layers above the bedrock consist dominantly of small angular fragments of sandstone. Approximately one-fifth of the Lithic Ustic Torriorthents are forming residually in materials weathered from limestone and have somewhat different profiles. These soils have brown or grayish-brown calcareous channery loam surface layers over subsoils that become lighter colored and more limy with depth. Angular fragments of limestone are common and may comprise 50 percent or more of the soil mass above the limestone bedrock that usually occurs within a depth of 20 inches.

Rock Land, a miscellaneous land type that makes up 20 percent of the association, commonly occupies the steep breaks and escarpments on the sides of mesas, hills, and upland ridges. It consists of a complex of shallow stony soils and outcrops of sandstone and other types of sedimentary rocks. A thin mantle of soil is generally found between the ledges or outcrops of bedrock. Although dominanted by shallow stony soils with highly variable characteristic, pockets or extremely small areas of moderately deep and deep soils occur intermingled with the outcrops of bedrock. The surface often contains boulders and stones.

Other soils and land types in this association include Alluvial Land, Gullied Land, and soils of Ustollic Calciorthid, Ustollic Haplargid, Cumulic Haplustoll, and Lithic Ustollic Haplargid subgroups. The Ustollic Calciorthids, which are underlain at shallow depths by soil layers high in lime, occur on gently to strongly sloping alluvial fans and side slopes of drainageways. They are medium-textured. The Ustollic Haplargids are deep soils with distinct and well developed subsoils that range in texture from sandy clay loam to clay. The Cumulic Haplustolls are the deep dark-colored medium- to moderately fine-textured soils that occur mainly in swales and depressional areas adjacent to drainages. The Lithic Ustollic Haplargids are shallow soils developing over interbedded sandstone and shale.

Representative soil series are: La Fonda, Alicia, Travessilla, Pinon, Rednun, Penistaja, Witt, and Newkirk.

Table 16. Comparative occurrence of soils in Israel (IS), Yuma Proving Grounds (YU), Fort Irwin, California (ER), Fort Huachuca, Arizona (HU), and White Sands Missile Range, New Mexico (WS)

Subgroup	Family	Map Location				
		IS	YU	ER	HU	WS
Saprists		xx1/	--	--	--	--
Typic Chromoxererts	fine, mixed, thermic	xx1/	--	--	xx	--
	fine, mixed, hyperthermic	xx1/	--	--	xx	--
Pelloxererts	fine, mixed, thermic	xx1/	--	--	--	--
	fine, mixed, hyperthermic	xx1/	--	--	--	--
Typic Paleargids	fine, mixed, thermic	--	--	--	xx	--
Petrocalcic Paleargids	loamy-skeletal, mixed, thermic	xx	--	--	--	--
	loamy-skeletal, mixed, hyperthermic	xx	--	--	--	--
Typic Natrargids	fine, montmorillonitic, thermic	--	--	--	xx	--
Typic Haplargids	coarse-loamy, mixed, thermic	xx	--	xx	--	xx
	coarse-loamy, mixed, hyperthermic	xx	xx	--	--	--
	fine-loamy, mixed, thermic	xx	--	xx	--	xx
	fine-loamy, mixed, hyperthermic	xx	xx	--	--	--
	loamy-skeletal, mixed, thermic	--	--	xx	--	xx
Lithic Haplargids	loamy-skeletal, mixed, hyperthermic	--	xx	--	--	--
Ustollic Haplargids	clayey, mixed, thermic, shallow	--	--	--	xx	--
	fine-loamy, mixed, mesic	--	--	--	xx	--
	fine, mixed, thermic	--	--	--	xx	--
	loamy-skeletal, mixed, thermic	--	--	--	xx	xx
Xeralfic Haplargids	coarse-loamy, mixed, thermic	--	--	xx	--	--
Typic Salorthids	sandy, mixed, hyperthermic	xx	--	--	--	--
	coarse-loamy, mixed, hyperthermic	xx	--	--	--	--
	fine-loamy, mixed, hyperthermic	xx	--	--	--	--
	fine, mixed, thermic	--	--	--	--	xx
	fine, mixed, hyperthermic	xx	--	--	--	--
Typic Paleorthids	loamy-skeletal, carbonatic, thermic, shallow	--	--	--	--	xx
Typic Durorthids	loamy-skeletal, mixed (nonacid), hyperthermic	--	xx	--	--	--

1/ These soils occur north of Beersheba in the nonarid portion of Israel.

Table 16. (Cont.) Comparative occurrence of soils in Israel (IS), Yuma Proving Grounds (YU), Fort Irwin, California (ER), Fort Huachuca, Arizona (HU), and White Sands Missile Range, New Mexico (WS)

Subgroup	Family	Map Location IS	YU	ER	HU	WS
Typic Gypsiorthids	coarse-loamy, gypsic, thermic	--	--	--	--	xx
Cambic Gypsiorthids	fine-loamy, mixed, hyperthermic	xx	--	--	--	--
	loamy-skeletal, mixed, hyperthermic	xx	--	--	--	--
Petrogypsic Gypsiorthids	fine-loamy, mixed, hyperthermic	xx	--	--	--	--
	loamy-skeletal, mixed, hyperthermic	xx	--	--	--	--
Typic Calciorthids	coarse-loamy, mixed, thermic	--	--	--	--	xx
	coarse-loamy, mixed, hyperthermic	--	xx	--	--	--
	coarse-loamy, carbonatic, hyperthermic	--	xx	--	--	--
	fine-loamy, mixed, thermic	--	--	--	--	xx
	fine-loamy, mixed, hyperthermic	xx	--	--	--	--
	sandy-skeletal, mixed, thermic	--	--	xx	--	--
	loamy-skeletal, mixed, thermic	--	--	--	--	xx
	loamy-skeletal, mixed, hyperthermic	--	xx	--	--	--
Aquic Calciorthids	fine-loamy, mixed, thermic	xx	--	--	--	--
	fine, mixed, thermic	xx	--	--	--	--
Lithic Calciorthids	loamy-skeletal, carbonatic, thermic	--	--	--	--	xx
Ustollic Calciorthids	fine-loamy, carbonatic, thermic	--	--	--	xx	--
Typic Camborthids	coarse-loamy, mixed, thermic	--	--	--	--	xx
	fine-loamy, mixed, mesic	--	--	--	--	xx
	fine-loamy, mixed, thermic	--	--	xx	--	--
	fine-loamy, mixed, hyperthermic	xx	--	--	--	--
	fine-silty, mixed, thermic	--	--	--	--	xx
	fine, illitic, thermic	--	--	--	--	xx
	fine, mixed, thermic	--	--	--	--	xx
Lithic Camborthids	loamy, mixed, thermic	--	--	xx	--	--
	loamy-skeletal, mixed, hyperthermic	--	xx	--	--	--
Ustollic Camborthids	fine-loamy, mixed, mesic	--	--	--	--	xx
	loamy-skeletal, mixed, thermic	--	--	--	--	xx
Argixerolls	fine, mixed, thermic	xx1/	--	--	--	--
Aridic Lithic Haploxerolls	coarse-loamy, mixed, thermic	xx	--	--	--	--
	coarse-loamy, mixed, hyperthermic	xx	--	--	--	--
	fine-loamy, mixed, thermic	xx	--	--	--	--
	fine-loamy, mixed, hyperthermic	xx	--	--	--	--

1/ These soils occur north of Beersheba in the nonarid portion of Israel.

Table 16. (Cont.) Comparative occurrence of soils in Israel (IS), Yuma Proving Grounds (YU), Fort Irwin, California (ER), Fort Huachuca, Arizona (HU), and White Sands Missile Range, New Mexico (WS)

Subgroup	Family	Map Location				
		IS	YU	ER	HU	WS
Entic Haploxerolls	coarse-loamy, mixed, thermic	xx1/	--	--	--	--
	fine-loamy, mixed, thermic	xx1/	--	--	--	--
	fine, mixed, thermic	xx1/	--	--	--	--
Lithic Haploxerolls	coarse-loamy, mixed, thermic	xx1/	--	--	--	--
	coarse-loamy, mixed, hyperthermic	xx1/	--	--	--	--
	fine-loamy, mixed, thermic	xx1/	--	--	--	--
	fine-loamy, mixed, hyperthermic	xx1/	--	--	--	--
	fine, mixed, thermic	xx1/	--	--	--	--
	fine, mixed, hyperthermic	xx1/	--	--	--	--
Vertic Haploxerolls	fine, mixed, thermic	xx1/	--	--	--	--
	fine, mixed, hyperthermic	xx1/	--	--	--	--
Aridic Calciustolls	loamy-skeletal, mixed, thermic	--	--	--	xx	--
Lithic Calciustolls	loamy, skeletal, carbonatic, mesic	--	--	--	--	xx
Petrocalcic Calciustolls	loamy, mixed, thermic, shallow	--	--	--	xx	--
Lithic Haplustolls	loamy-skeletal, mixed, mesic	--	--	--	xx	--
	loamy-skeletal, carbonatic, mesic	--	--	--	xx	--
	loamy-skeletal, mixed, thermic	--	--	--	xx	--
	loamy-skeletal, carbonatic, thermic	--	--	--	xx	--
Torriorthentic Haplustolls	coarse-loamy, mixed, thermic	--	--	--	--	xx
Udorthentic Haplustolls	loamy, mixed, mesic, shallow	--	--	--	xx	--
Lithic Argiustoll	clayey, montmorillonitic, thermic	--	--	--	xx	--
Udic Argiustolls	fine, montmorillonitic, mesic	--	--	--	xx	--
Typic Albaqualfs	fine-loamy, mixed, thermic	xx1/	--	--	--	--
	fine, mixed, thermic	xx1/	--	--	--	--
Aeric Albaqualfs	fine-loamy, mixed, thermic	xx1/	--	--	--	--
	fine, mixed, thermic	xx1/	--	--	--	--

1/ These soils occur north of Beersheba in the nonarid portion of Israel.

Table 16. (Cont.) Comparative occurrence of soils in Israel (IS), Yuma Proving Grounds (YU), Fort Irwin, California (ER), Fort Huachuca, Arizona (HU), and White Sands Missile Range, New Mexico (WS)

Subgroup	Family	Map Location				
		IS	YU	ER	HU	WS
Udic Haplustalfs	fine, illitic, mesic	--	--	--	xx	--
Typic Rhodoxeralfs	coarse-loamy, mixed, thermic	xx1/	--	--	--	--
	fine-loamy, mixed, thermic	xx1/	--	--	--	--
	fine, mixed, thermic	xx1/	--	--	--	--
Calcic Rhodoxeralfs	fine-loamy, mixed, thermic	xx1/	--	--	--	--
	fine, mixed, thermic	xx1/	--	--	--	--
Petrocalcic Palexeralfs	loamy-skeletal, mixed, thermic	xx1/	--	--	--	--
Calcic Haploxeralfs	coarse-loamy, mixed, thermic	xx1/	--	--	--	--
	coarse-loamy, mixed, hyperthermic	xx1/	--	--	--	--
	fine-loamy, mixed, thermic	xx1/	--	--	--	--
	fine-loamy, mixed, hyperthermic	xx1/	--	--	--	--
	loamy-skeletal, mixed, thermic	xx1/	--	--	--	--
Mollic Haploxeralfs	fine-loamy, mixed, thermic	xx1/	--	--	--	--
Vertic Haploxeralfs	fine-loamy, mixed, thermic	xx1/	--	--	--	--
	fine-loamy, mixed, hyperthermic	xx1/	--	--	--	--
	fine-silty, mixed, thermic	xx1/	--	--	--	--
	fine-silty, mixed, hyperthermic	xx1/	--	--	--	--
Typic Haplaquepts	fine, mixed, thermic	xx1/	--	--	--	--
Aeric Haplaquepts	fine-loamy, mixed, thermic	xx1/	--	--	--	--
	fine, mixed, thermic	xx1/	--	--	--	--
Calcixerollic Xerochrepts	coarse-loamy, mixed, thermic	xx1/	--	--	--	--
	coarse-loamy, mixed, hyperthermic	xx1/	--	--	--	--
	fine-loamy, mixed, thermic	xx1/	--	--	--	--
	fine-loamy, mixed, hyperthermic	xx1/	--	--	--	--
	loamy-skeletal, mixed, thermic	xx1/	--	--	--	--
Lithic Xerochrepts	coarse-loamy, mixed, thermic	xx1/	--	--	--	--
Vertic Lithic Xerochrepts	fine, mixed, thermic	xx1/	--	--	--	--
	fine, mixed, hyperthermic	xx1/	--	--	--	--

1/ These soils occur north of Beersheba in the nonarid portion of Israel.

Table 16. (Cont.) Comparative occurrence of soils in Israel (IS), Yuma Proving Grounds (YU), Fort Erwin, California (ER), Fort Huachuca, Arizona (HU), and White Sands Missile Range, New Mexico (WS)

Subgroup	Family	Map Location				
		IS	YU	ER	HU	WS
Vertic Xeroxhrepts	fine-loamy, mixed, thermic	xx1/	--	--	--	--
	fine-loamy, mixed, hyperthermic	xx1/	--	--	--	--
	fine-silty, mixed, thermic	xx1/	--	--	--	--
	fine-silty, mixed, hyperthermic	xx1/	--	--	--	--
	fine, mixed, thermic	xx1/	--	--	--	--
	fine, mixed, hyperthermic	xx1/	--	--	--	--
Haplaquents	fine, mixed, thermic	xx1/	--	--	--	--
Quartzipsamments	thermic	xx	--	--	--	--
Typic Torripsamments	mixed, thermic	xx	--	xx	--	xx
	mixed, hyperthermic	xx	xx	--	--	--
Xeric Torripsamments	mixed, thermic	xx	--	xx	--	--
Lithic Xeropsamments	mixed, thermic	xx1/	--	--	--	--
Typic Xerofluvents	sandy, mixed, hyperthermic	xx	--	--	--	--
	coarse-silty, mixed, hyperthermic	xx	--	--	--	--
Typic Torrifluvents	sandy, mixed, thermic	--	--	xx	--	--
	sandy, mixed, hyperthermic	xx	xx	--	--	--
	coarse-loamy, mixed, thermic	--	--	xx	--	--
	coarse-loamy, mixed, hyperthermic	--	xx	--	--	--
	fine-loamy, mixed, thermic	--	--	xx	--	--
	fine-loamy, mixed, hyperthermic	xx	--	--	--	--
	fine-silty, mixed, thermic	--	--	--	--	xx
	fine, mixed, thermic	--	--	--	xx	--
	loamy-skeletal, mixed, hyperthermic	xx	--	--	--	--
Anthropic Torrifluvent	fine-silty, mixed, thermic	--	--	--	xx	--
Ustic Torrifluvents	fine, mixed, thermic	--	--	--	--	xx
Typic Torriorthents	sandy, mixed, hyperthermic	--	xx	--	--	--
	coarse-loamy, mixed, hyperthermic	xx	--	--	--	--
	fine-loamy, mixed, thermic	xx	--	--	--	xx
	fine-loamy, mixed, hyperthermic	xx	--	--	--	--
	fine-loamy, gypsic, thermic	--	--	--	--	xx
	sandy-skeletal, mixed, thermic	--	--	xx	--	--
	loamy-skeletal, mixed, thermic	--	--	xx	--	--

1/ These soils occur north of Beersheba in the nonarid portion of Israel.

Table 16. (Cont.) Comparative occurrence of soils in Israel (IS), Yuma Proving Grounds (YU), Fort Irwin, California (ER), Fort Huachuca, Arizona (HU), and White Sands Missile Range, New Mexico (WS)

Subgroup	Family	Map Location				
		IS	YU	ER	HU	WS
Lithic Torriorthents	coarse-loamy, mixed, thermic	xx	--	--	--	--
	coarse-loamy, mixed, hyperthermic	xx	--	--	--	--
	fine-loamy, mixed, thermic	xx	--	--	--	--
	fine-loamy, mixed, hyperthermic	xx	--	--	--	--
Typic Xerorthents	coarse-loamy, mixed, thermic	xx1/	--	--	--	--
	coarse-loamy, mixed, hyperthermic	xx1/	--	--	--	--
	fine-loamy, mixed, thermic	xx1/	--	--	--	--
	fine-loamy, mixed, hyperthermic	xx1/	--	--	--	--
	fine, mixed, thermic	xx1/	--	--	--	--
	fine, mixed, hyperthermic	xx1/	--	--	--	--
Lithic Xerorthents	coarse-loamy, mixed, thermic	xx1/	--	--	--	--
	coarse-loamy, mixed, hyperthermic	xx1/	--	--	--	--
	fine-loamy, mixed, thermic	xx1/	--	--	--	--
	fine-loamy, mixed, hyperthermic	xx1/	--	--	--	--
	fine, mixed, thermic	xx1/	--	--	--	--
	fine, mixed, hyperthermic	xx1/	--	--	--	--
Typic Ustorthent	loamy-skeletal, mixed, mesic	--	--	--	xx	--
Lithic Ustorthents	loamy-skeletal, mixed, mesic	--	--	--	xx	--

1/ These soils occur north of Beersheba in the nonarid portion of Israel.

SUMMARY AND CONCLUSIONS

The soils of Israel were evaluated in terms of texture, parent material, mineralogy, and chemical and physical features. They were classified according to the USDA Soil Taxonomy (Soil Survey Staff, 1975).

Southern Israel is dominated by Aridisols which are soils which lack moisture during the growing season for plants. This order dominates much of the Middle East. Many of the soils in the wadi beds and associated alluvial plains are Entisols, which lack any pedogenic differentiation. The major horizon differentiation in the arid areas has been due to calcium carbonate redistribution within the soil. Soils on the stable uplands in the arid Middle East have argillic horizons as well as calcic horizons and are classified as Typic Haplargids. The less stable areas which have soil development features have Calciorthids. The recent depositional and erosional surfaces have Torrifluvents and Torriorthents. Many of the soils in closed basins or which are heavily influenced by gypsiferous parent material are Gypsiorthids. Most of the profile differentiation, whether just calcium carbonate redistribution or due to illuviation of silicate clay, is a result of paleoclimatic influence.

The soils of the entire area of Israel are discussed; however, only those areas in the CONUS which have similarity to the southern part of Israel (the Negev Desert) are discussed. The area near the coast of southern California has some similarity to northern Israel. The northern part of Israel has a mediterranean climate.

The parent materials of the soils of the northern Negev are dominantly loess, which is a wind blown, silt dominated soil material. This parent material is not dominant in any of the four compared areas of the United States which have soils classified in similar families.

Among the areas evaluated in the United States, the two areas which are closest to the soils of the Negev are the Yuma Proving Grounds in Arizona and Fort Irwin in California. The Yuma Proving Grounds are dominated by soils with hyperthermic temperatures. The parent materials are mainly igneous or alluvium derived from igneous rocks. This is markedly different than the soil parent materials around Beersheba. Fort Erwin has thermic soil temperatures. Thermic soils are similar to the northern Negev and hyperthermic soils are similar to the southern Negev. The soils of Fort Huachuca, Arizona, have more moisture than common in the Negev. The White Sands Missile Range in New Mexico has thermic soils and soils of similar texture and parent material; however, the rainfall occurs in the summer as compared to the winter for Israel.

Table 16 can be used for comparing soils of the five areas. Similar families, subgroups, great groups, suborders and orders can be compared.

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GLOSSARY 1/

A horizon: Mineral horizons consisting of: (i) horizons of organic-matter accumulation formed or forming at or adjacent to the surface; (ii) horizons that have lost clay, iron, or aluminum with resultant concentration of quartz or other resistant minerals of sand or silt size; or (iii) horizons dominated by (i) or (ii) above but transitional to an underlying B or C.

Alluvial fan: A body of alluvium, with or without debris flow deposits, whose surface forms a segment of a cone that radiates downslope from the point where the stream emerges from a narrow valley onto a plain. Common longitudinal profiles are gently sloping and nearly linear. Source uplands range in relief and areal extent from mountains and plateaus to gullied terrains on hill and piedmont slopes.

Alluvium: Unconsolidated clastic material deposited by running water, including gravel, sand, silt, clay and various mixtures of these.

Anticline: a unit of folded strata that is convex upward. In a single anticline beds forming the opposing limbs of the fold dip away from its axial plane.

Argillic Horizon: A mineral soil horizon that is characterized by the illuvial accumulation of layer-lattice silicate clays. The argillic horizon has a certain minimum thickness depending on the thickness of the solum, a minimum quantity of clay in comparison with an overlying eluvial horizon depending on the clay content of the éluvial horizon, and usually has coatings of oriented clay on the surface of pores or peds or bridging sand grains.

Aridic: A soil moisture regime that has no moisture available for plants for more than half the cumulative time that the soil temperature at 50 cm is above 5C, and has no period as long as 90 consecutive days when there is moisture for plants while the soil temperature at 50 cm is continuously above 8C. Torric is a synonym for aridic used in the USDA Soil Taxonomy at the Great Group level.

B Horizon: Horizons in which the dominant feature or features i ,ne or more of the following: (i) an illuvial concentration of silicate clay, iron, aluminum, or humus, alone or in combination; (ii) a residual concentration of sesquioxides or silicate clays, alone or mixed, that has formed by means other than solution and removal of carbonates or more soluble salts; (iii) coatings of sesquioxides adequate to give conspicuously darker, stronger, or redder colors than overlying and underlying horizons in the same sequum but without apparent illuviation of iron and not genetically related to B horizons that meet requirements of (i) or (ii) in the same sequum; or (iv) an alteration of material from its original condition in sequums lacking conditions defined in (i), (ii), and (iii) that obliterates original rock structure, that forms silicate clays, liberates oxides, or both, and that forms granular, blocky, or prismatic structure if textures are such that volume changes accompany changes in moisture.

Bb Horizon: A B horizon which has been buried by a geologic deposition of younger parent material, such as loess or alluvium.

Bca Horizon: An accumulation of carbonates of alkaline earths, commonly of calcium, in the B horizon. The horizon must have more carbonates than the parent material is presumed to have had.

Bcs Horizon: An accumulation of calcium sulfate in the B horizon. The horizon must have more sulfates (gypsum) than the parent material is presumed to have had.

C Horizon: A mineral horizon or layer, excluding bedrock, that is either like or unlike the material from which the solum is presumed to have formed, relatively little affected by pedogenic processes, and lacking properties diagnostic of A or B but including materials modified by: (i) weathering outside the zone of major biological activity; (ii) reversible cementation, development of brittleness, development of high bulk density, and other properties characteristic of fragipans; (iii) gleying; (iv) accumulation of calcium or magnesium carbonate (Cca horizon) or more soluble salts (Ccs and Csa horizons); (v) cementation by accumulations such as calcium or magnesium carbonate or more soluble salts; or (vi) cementation by alkali-soluble siliceous material or by iron and silica.

Calcic Horizon: A mineral soil horizon of secondary carbonate enrichment that is more than 15 cm thick, has a calcium carbonate equivalent of more than 15%, and has at least 5% more calcium carbonate equivalent than the underlying C horizon.

Caliche: A layer near the surface, more or less cemented by secondary carbonates of calcium or magnesium precipitated from the soil solution. It may occur as a soft thin soil horizon, as a hard thick bed just beneath the solum, or as a surface layer exposed by erosion.

Cambic Horizon: A mineral soil horizon that has a texture of loamy very fine sand or finer, has soil structure rather than rock structure, contains some weatherable minerals, and is characterized by the alteration or removal of mineral material as indicated by mottling or gray colors, stronger chromas or redder hues than in underlying horizons, or the removal of carbonates. The cambic horizon lacks cementation or induration and has too few evidences of illuviation to meet the requirements of the argillic horizon.

Cation-Exchange Capacity (CEC): The sum total of exchangeable cations that a soil can adsorb. Expressed in milliquivalents per 100 grams or per gram of soil.

Channery: Thin, flat fragments of limestone, sandstone, or schist up to 6 inches in major diameter.

Clastic: Pretaining to a rock or sediment composed mainly of fragments derived from preexisting rocks or minerals and moved from their place of origin.

Cutans: Coatings of clay on the surfaces of soil peds and mineral grains and in soil pores. (Also called clay films, clay skins, clay flows and argillans).

Detritus: Rock and mineral fragments occurring in sediments that were derived from preexisting igneous, sedimentary, or metamorphic rocks.

Duripan: A mineral soil horizon that is cemented by silica, usually opal or microcrystalline forms of silica, to the point that air-dry fragments will not slake in water or HCl. A duripan may also have accessory cement such as iron oxide or calcium carbonate.

Eolian: Pertaining to material transported and deposited by the wind. Includes earth materials ranging from dune sands to silty loess deposits.

Exchangeable-Sodium Percentage (ESP): The percentage of the cation-exchange capacity of a soil occupied by sodium. It is expressed as follows:

$$ESP = \frac{\text{Exchangeable sodium (meq/100g soil)} \times 100}{\text{Cation-exchange capacity (meq/100g soil)}}$$

Flood Plain: The nearly level alluvial plain that borders a stream and is subject to inundation under flood-stage conditions unless protected artificially. It is usually a constructional landform built of sediment deposited during overflow and lateral migration of the stream.

Gilgai: The microrelief of soils produced by expansion and contraction with changes in moisture. Found in soils that contain large amounts of clay which swells and shrinks considerably with wetting and drying. Usually a succession of microbasins and microknolls in nearly level areas or of microvalleys and microridges parallel to the direction of the slope.

Gley: A soil feature developed under conditions of poor drainage resulting in reduction of iron and other elements and in gray colors and mottles.

Gypsic Horizon: A mineral soil horizon of secondary calcium sulfate enrichment that is more than 15 cm thick, has at least 5% more gypsum than the C horizon, and in which the product of the thickness in centimeters and the percent calcium sulfate is equal to or greater than 150% cm.

Illite: A silicate clay with 2:1 lattice structure, but of indefinite chemical composition since usually part of the silicon in the silica tetrahedral layer has been replaced by aluminum, and containing a considerable amount of potassium which serves as an additional bonding between the crystal units, resulting in particles larger than normal in montmorillonite and, consequently, in a lower cation-exchange capacity. Usually referred to as hydrous mica.

Illuvial Horizon: A soil layer or horizon in which material carried from an overlying layer has been precipitated from solution or deposited from suspension. The layer of accumulation.

Kaolin: (i) An aluminosilicate mineral of the 1:1 crystal lattice group; that is, consisting of one silicon tetrahedral layer and one aluminum oxide-hydroxide octahedral layer. (ii) The 1:1 group or family of aluminosilicates.

Lacustrine Deposit: Material deposited in lake water and later exposed either by lowering the water level or by the elevation of the land.

Loess: Material transported and deposited by wind and consisting of predominantly silt-sized particles.

Mollic Epipedon: A surface horizon of mineral soil that is dark colored and relatively thick, contains at least 0.58% organic carbon, is not massive and hard or very hard when dry, has a base saturation of more than 50% when measured at pH 7, has less than 250 ppm of P2O5 soluble in 1% citric acid, and is dominantly saturated with bivalent cations.

Montmorillonite: An aluminosilicate clay mineral with a 2:1 expanding crystal structure, that is, with two silicon tetrahedral layers enclosing an aluminum octahedral layer. Considerable expansion may be caused along the C axis by water moving between silica layers of contiguous units.

Natric Horizon: A mineral soil horizon that satisfied the requirements of an argillic horizon, but that also has prismatic, columnar, or blocky structure and a subhorizon having more than 15% saturation with exchangeable sodium.

Ochric Epipedon: A surface horizon of mineral soil that is too light in color, too high in chroma, too low in organic carbon, or too thin to be a plaggen, mollic umbric, anthropic or histic epipedon, or that is both hard and massive when dry.

Paleosol, Buried: A soil formed on a landscape during the geologic past and subsequently buried by sedimentation.

Ped: A unit of soil structure such as an aggregate, crumb, prism, block, or granule, formed by natural processes (in contrast with a clod, which is formed artificially).

Pedon: A three-dimensional body of soil with lateral dimensions large enough to permit the study of horizon shapes and relations.

Pediment: A gently sloping erosional surface developed at the foot of a receding hill or mountain slope. The surface may be essentially bare, exposing earth material that extends beneath adjacent uplands; or it may be thinly mantled with alluvium and colluvium, ultimately in transit from upland front to basin or valley lowland.

Permeability, Soil: The ease with which gases, liquids, or plant roots penetrate or pass through a bulk mass of soil or a layer of soil.

Petrocalcic Horizon: A continuous, indurated calcic horizon that is cemented by calcium carbonate and, in some places, with magnesium carbonate. It cannot be penetrated with a spade or auger when dry; dry fragments do not slake in water, and it is impenetrable to roots.

Petrogypsic Horizon: A continuous, strongly cemented, massive, gypsic horizon that is cemented by calcium sulfate. It can be chipped with a spade when dry. Dry fragments do not slake in water and it is impenetrable to roots.

Pleistocene: The first epoch of the Quaternary Period of geologic time, following the Tertiary Pliocene Epoch and preceding the Holocene (approx. from 2 million to 10 thousand years ago).

Pluvial: The rainy period in nonglaciated regions which corresponds to the glacial maxima of the ice-covered regions. Pluvial and interpluvial are terms sometimes used in the same way as glacial and interglacial.

Profile, Soil: A vertical section of the soil through all its horizons and extending into the parent material.

Quaternary: The second period of the Cenozoic Era of geologic time, extending from the end of the Tertiary Period (about 2 million years ago) to the present and comprising two epochs, the Pleistocene (Ice Age) and the Holocene (Recent).

R Horizon: Underlying consolidated bedrock, such as granite, sandstone, or limestone. If presumed to be like the parent rock from which the adjacent overlying layer or horizon was formed, the symbol R is used alone. If presumed to be unlike the overlying material, the R is preceded by a Roman numeral denoting lithologic discontinuity.

Regolith: The unconsolidated mantle of weathered rock and soil material on the earth's surface; loose earth materials above solid rock.

Residuum: Unconsolidated, weathered, or partly weathered mineral material that accumulates by disintegration of bedrock in place.

Salic Horizon: A mineral soil horizon of enrichment with secondary salts more soluble in cold water than gypsum. A salic horizon is 15 cm or more in thickness, contains at least 2% salt, and the product of the thickness in centimeters and percent salt by weight is 60% cm or more.

Slickensides: Polished and grooved surfaces produced by one mass sliding past another. Slickensides are common in Vertisols.

Soil: The unconsolidated mineral matter on the surface of the earth that has been subjected to and influenced by genetic and environmental factors of: parent material, climate (including moisture and temperature effects), macro- and microorganisms, and topography, all acting over a period of time and producing a product--soil--that differs from the material from which it is derived in many physical, chemical, biological and morphological properties, and characteristics.

Soil Association: A mapping unit used on general soil maps, in which two or more defined taxonomic units occurring together in a characteristic pattern are combined because the scale of the map or the purpose for which it is being made does not require delineation of the individual soils.

Soil Horizon: A layer of soil or soil material approximately parallel to the land surface and differing from adjacent genetically related layers in physical, chemical, and biological properties or characteristics such as color, structure, texture, consistency, kinds and numbers of organisms present, degree of acidity or alkalinity, etc.

Soil Structure: The combination or arrangement of primary soil particles into secondary particles, units, or peds. These secondary units may be, but usually are not, arranged in the profile in such a manner as to give a distinctive characteristic pattern. The secondary units are characterized and classified on the basis of size, shape, and degree of distinctness into classes, types, and grades, respectively.

Solum: The upper and most weathered part of the soil profile; the A and B horizons.

Stream Terrace: One of a series of platforms in a stream valley, flanking and more or less parallel to the stream channel, originally formed near the level of the stream, and representing the dissected remnants of an abandoned flood plain, stream bed, or valley floor produced during a former stage of erosion or deposition. Remnants of constructional valley floors are termed "alluvial terraces".

Syncline: A unit of folded strata that is concave upward. In a simple syncline, beds forming the opposing limbs of the fold dip toward its axial plane.

Udic: A soil moisture regime that is neither dry for as long as 90 cumulative days nor for as long as 60 consecutive days in the 90 days following the summer solstice at periods when the soil temperature at 50 cm is above 5C.

Umbric Epipedon: A surface layer of mineral soil that has the same requirements as the mollic epipedon with respect to color, thickness, organic carbon content, consistence, structure, and P_2O_5 content, but that has a base saturation of less than 50% when measured at pH 7.

Ustic: A soil moisture regime that is intermediate between the aridic and udic regimes and common in temperate subhumid or semiarid regions, or in tropical and subtropical regions with a monsoon climate. A limited amount of moisture is available for plants but occurs at times when the soil temperature is optimum for plant growth.

Xeric: A soil moisture regime common to Mediterranean climates that have moist cool winters and warm dry summers. A limited amount of moisture is present but does not occur at optimum periods for plant growth. Irrigation or summerfallow is commonly necessary for crop production.

1/ Most of the glossary terms are derived from SSSA (1975) and Hawley (1976).

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